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Clean Water Report for Southwestern Wyoming

CH2M/Hill
Denver, CO

Prepared for

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Aug 78

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The results of three years of water quality investigations in Southwestern Wyoming are presented. This report identifies the most pressing regional water quality problems for Lincoln, Uinta and Sweetwater Counties, assesses their impacts on the health and welfare of citizens in the area, and recommends alternatives to correct the problems. Three major problems were identified in this study. They are excessive salinity in the Green River Basin, excessive algae growth in reservoirs, and bacterial contamination of water supply wells and surface waters. Several other water quality problems of less regional significance are presented. Some discussion of impacts of energy development in the area is also given.

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CLEAN WATER REPORT FOR SOUTHWESTERN WYOMING
FINAL TECHNICAL REPORT

Prepared for
The Southwestern Wyoming Water Qaulity Planning Association

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August 1978

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Eugene B. Martin,
Chairman

Southwestern Wyoming Water Quality
Planning Association

P.O. Box 389 | **Kemmerer, Wyoming 83101** | **(307) 877-3984**

August 1, 1978

Dear Members and Friends:

Transmitted herewith is a copy of the "Final Technical Report for Southwestern Wyoming," as prepared by CH2M-Hill, Inc., Denver, Colorado.

This report is to be considered as the final plan for water quality planning and management for Lincoln, Sweetwater, and Uinta Counties in Southwestern Wyoming. The management plan is required by Public Law 92-500 of the Water Pollution Control Act of 1972, as amended.

This document was widely distributed to gain imput into the recommendations and conclusions reached in the report. A series of public hearings were held on this report in November 1977. They were held jointly with the State of Wyoming, Environmental Quality Council. The input from citizens and agencies at these hearings and during subsequent review stages is appreciated and hereby acknowledged.

Sincerely,

Eugene B Martin

EUGENE B. MARTIN
Chairman

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Enclosure

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27 July 1978

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Southwestern Wyoming Water
 Quality Planning Association
P.O. Box 389
Kemmerer WY 83101

Attention: Mr. Eugene B. Martin
Chairman

Gentlemen:

Submitted herewith, please find the Final Technical Report in accordance with our contract with your Association. This report includes the consultant's recommended plan for water quality management. CH2M HILL will publish a report which describes the plan adopted by the Association.

It has been enjoyable working with you during the preparation of the Final Technical Report.

Very truly yours,

William L. Sinclair

William L. Sinclair
Project Administrator

cf

Denver Office
12000 E. 17th Avenue, Denver, Colorado 80239 303/371-6470

CLEAN WATER REPORT FOR SOUTHWESTERN WYOMING
FINAL TECHNICAL REPORT

Prepared for
The Southwestern Wyoming Water Qaulity Planning Association

Prepared by

CH2M HILL, INC.
12000 East 47th Avenue
Denver, Colorado 80239

August 1978

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ACKNOWLEDGEMENTS

This Technical Report presents a discussion of the water quality problems in Southwestern Wyoming and a water quality management plan recommended by the staff of the Southwestern Wyoming Water Quality Planning Association and its consultants. The plan is the result of 3 years of technical research on the water quality needs of the area.

CH2M HILL is grateful for the technical assistance provided by the Association staff, by the Wyoming Water Resources Research Institute (WRRI), and by Nelson Engineering, Inc., in the development of the water quality management plan. A special note of thanks is extended to Mr. Jerry Miller of the Association staff for his work on ground water and to Mr. Barry Weand of WRRI for his work on modeling future water quality.

CH2M HILL also would like to acknowledge those who have reviewed the interim reports and who have contributed strongly to the political, legal, and administrative elements of the recommended plan. Those who have been particularly active in the review process are the Technical Advisory Committee members, Mr. Bruce Zander of the United States Environmental Protection Agency, Mr. Larry Robinson of the Wyoming Department of Environmental Quality, Mr. Robert Schuetz and Mr. Richard Jentzsch of the Association staff, and the local citizens who have attended the public hearings and submitted written comments.

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Chapter 1
INTRODUCTION

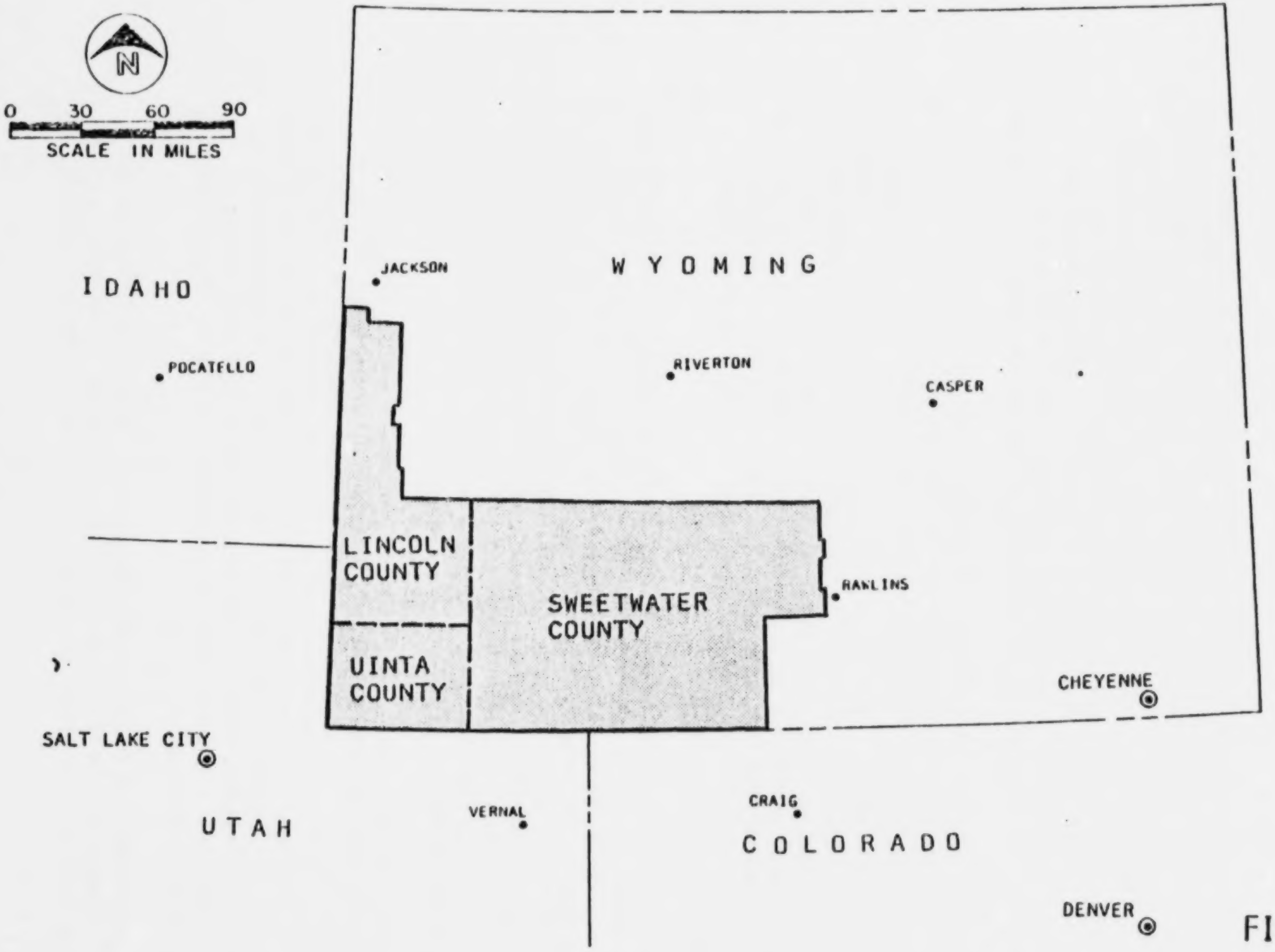
Early impressions of water quality in Southwestern Wyoming are recorded in the names given to streams in the area, such as Muddy Creek, Bitter Creek, Salt Wells Creek, Killpecker Creek, Sweetwater Creek, and Salt River. As indicated by these names, the water was found to be undesirable for many uses due to natural conditions. These conditions include highly erodible soils, some of which are highly saline, and a desert climate that keeps flows at low levels except for large storm events. To achieve water quality suitable for recreational, agricultural, domestic, and industrial uses in Southwestern Wyoming may mean changing or controlling natural processes.

The mineral wealth of Southwestern Wyoming, along with lands suitable for farming and ranching, has brought increasing numbers of people to the area. In less than 5 years the population in Sweetwater County has more than doubled. Because the study area is big--16,000 square miles--the 1975 population of 57,000 for the three-county area still amounted to an average density of only about 3.5 persons per square mile. However, continued development and population growth is expected in the area. As a result, although natural conditions predominantly influenced water quality in the past, future conditions will be much more sensitive to man's presence through such activities as mining, irrigating, and the building of dams, highways, and communities.

The water quality plan for Southwestern Wyoming focuses on achieving the desired water quality for the short term by various control actions and uses preventative measures to maintain that quality in the future. This report presents the technical basis for water quality management in Southwestern Wyoming and a 208 Water Quality Management Plan recommended by the staff of the Southwestern Wyoming Water Quality Planning Association (SWWQPA) and its consultants. The locally adopted final plan will be described in a shorter, separate report entitled "Management Plan, Clean Water Report for Southwestern Wyoming" (CH2M HILL, August 1978).

A 208 Plan describes how an area's water resources should be managed to maintain and improve water quality. It is named after Section 208 of Public Law 92-500. This law is the Federal Water Pollution Control Act Amendments of 1972 or, as more popularly known, the 1972 Clean Water Act. Under Section 208, state governors can designate special areas where there is a concern for existing and/or future water quality. These areas are then eligible to receive grants under Section 208 to carry out a 2-year planning program to develop specific management plans for maintaining and improving water quality.

In addition to designating the area, the governor also must designate an agency to carry out the planning. For the Counties of Sweetwater, Lincoln, and Uinta in Wyoming, shown on Figure 1-1, the Southwestern Wyoming Water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POCATELLO
WYOMING
JACKSON
RIVERTON
CASPER
RAWLINS
CHEYENNE
LINCOLN COUNTY
UINTA COUNTY
SWEETWATER COUNTY
SALT LAKE CITY
UTAH
VERNAL
CRAIG
COLORADO
DENVER

FIGURE 1-1

LOCATION OF STUDY AREA

CH2M HILL

Quality Planning Association (SWWQPA) was formed by the county commissioners and the incorporated cities for the purpose of doing this 208 Plan. The Association was formed in November 1975 with offices in Evanston. Various outside consulting firms were employed by the Association to help produce the work needed to develop a plan.

This report by the consultants and the Association's staff describes the area's water quality situation and the control plans proposed for managing the water resources. The report attempts to provide information to three groups of people: the general public who may be interested in the technical details of the work, the elected officials who must make decisions about carrying out the plan, and the technical people who will work with many details of the plan and who will advise the elected officials.

Staff and consultants have found numerous problems and issues that could be addressed, some of which are very important to individual people. However, early in the study the decision was made to concentrate on those water quality aspects which were considered to be most important from an areawide perspective and for which an improvement plan could be implemented. With this approach, planning efforts were not drained by covering all identified water quality problems and producing a long list of controls, many of which would not be practical to implement. As a result, certain issues or problems may not be covered to the satisfaction of some readers. However, the intent of the report is to present to the decision-makers, the general public, and the technical audience a very practical discussion of Southwestern Wyoming's water quality situation.

WHAT IS A 208 PLAN?

The 208 Plan is one part of the continuous planning process which constitutes the 208 program. The goal of this program is to have in operation at all times the most cost-effective management controls for the identified water quality problems. As defined by the Environmental Protection Agency (EPA), the most cost-effective control will have the least cost to society without any overriding adverse environmental, social, or institutional impacts. This 208 Plan should be updated as more water quality data become available, new water quality problems arise, and new control technology and institutional arrangements develop.

A 208 Plan addresses the water quality of streams, lakes and reservoirs, and ground water bodies. It is a comprehensive consideration of all types of pollution sources, management controls, and implementation factors. Pollution sources are identified as either point sources or nonpoint sources. Point sources are simply described as those that are captured in a pipe or ditch and discharged directly to a stream or lake, whereas nonpoint sources are those that are more dispersed, such as runoff due to rainfall. Most point sources are under the administration of the National Pollutant Discharge Elimination System (NPDES) of discharge permits. Nonpoint sources, on the other hand, are generally administered not through the permit program, but through a program of Best Management Practices (BMP's).

Point Sources

Traditionally, management of water quality has been concerned with the control of point sources only and has been almost exclusively limited to control of municipal and industrial treatment plant discharges. By the late 1970's, secondary treatment of municipal wastes will be widespread through Wyoming and the country. By the mid- to late 1980's, it is a national goal to have advanced wastewater treatment for certain serious pollutants.

The 208 Plan recommends the changes in point source treatment that must be made in order to achieve a desired level of water quality. These recommended changes have a far-reaching impact, because any municipality which seeks Federal funds through the 201 Wastewater Facility Planning Program must design for the changes recommended by an approved 208 Plan.

Nonpoint Sources

Study and control of nonpoint sources has come about because elimination of point source pollution in many areas has not produced the desired water quality. Water quality problems persisted because of pollution delivered by septic tanks and by runoff from urban lands, rural lands, rangelands, and areas of mining and silviculture. Because point sources were emphasized first, many of the factors involved in nonpoint control are not well developed. The effectiveness of many BMP's is impossible to predict without in-situ testing. The costs and secondary environmental impacts are difficult to predict accurately. Finally, the responsibilities for implementing, administering, and paying for BMP's are largely undefined.

Because of all the uncertainties surrounding BMP's, 208 Plans to date have not been as specific about nonpoint controls as point controls. This 208 Plan also is more specific on controls necessary for point sources than for nonpoint sources. While the Plan has identified relatively small regions within the study area where nonpoint controls are necessary to produce desired water quality, for many of these regions it has only been able to suggest nonpoint controls which might work or institutional arrangements which might be feasible. It has emphasized that in certain regions detailed feasibility studies need to be done. Therefore, while specific controls have not been defined for all identified water quality problems in the area, mechanisms have been set up to lead to the eventual alleviation of these problems.

The Technical Report

The goal of this Plan is to provide a process which will lead to a water quality acceptable to the local citizens, the State of Wyoming, and the Federal Government. In order to reach this goal, the Technical Report has sought to answer the following questions:

- What are the water quality goals for the local citizens, the State and the Federal Government (Chapter 2)?

- What are the existing water quality problems and what are their impacts (Chapters 3 and 4)?
- What are the contaminant sources causing these problems (Chapter 5)?
- What water quality problems are predicted for the future (Chapter 6)?
- What institutional framework exists for solving present and future water quality problems (Chapter 7)?
- What are the options (Chapter 8, Chapter 9, and Chapter 10)?
- What is the Plan recommended by the SWWQPA staff and consultants (Chapter 11)?

A draft Technical Report, published September 1977, has gone through public hearings and public review. Changes have been made in the draft from the comments received. This final Technical Report, along with an accompanying volume entitled "Management Plan," will be presented to SWWQPA for adoption.

The adopted 208 Plan must be considered in the context of the continuous planning process set up under Section 208 of the 1972 Clean Water Act. It is not a final plan. It should be updated as more information becomes available. For example, the State of Wyoming adopted a set of water quality standards in 1974, but is now in the process of developing new standards based on new water quality information. As a result, the criteria developed in Chapter 2 may need to be revised when the new set is adopted.

DESCRIPTION OF THE SOUTHWESTERN WYOMING AREA

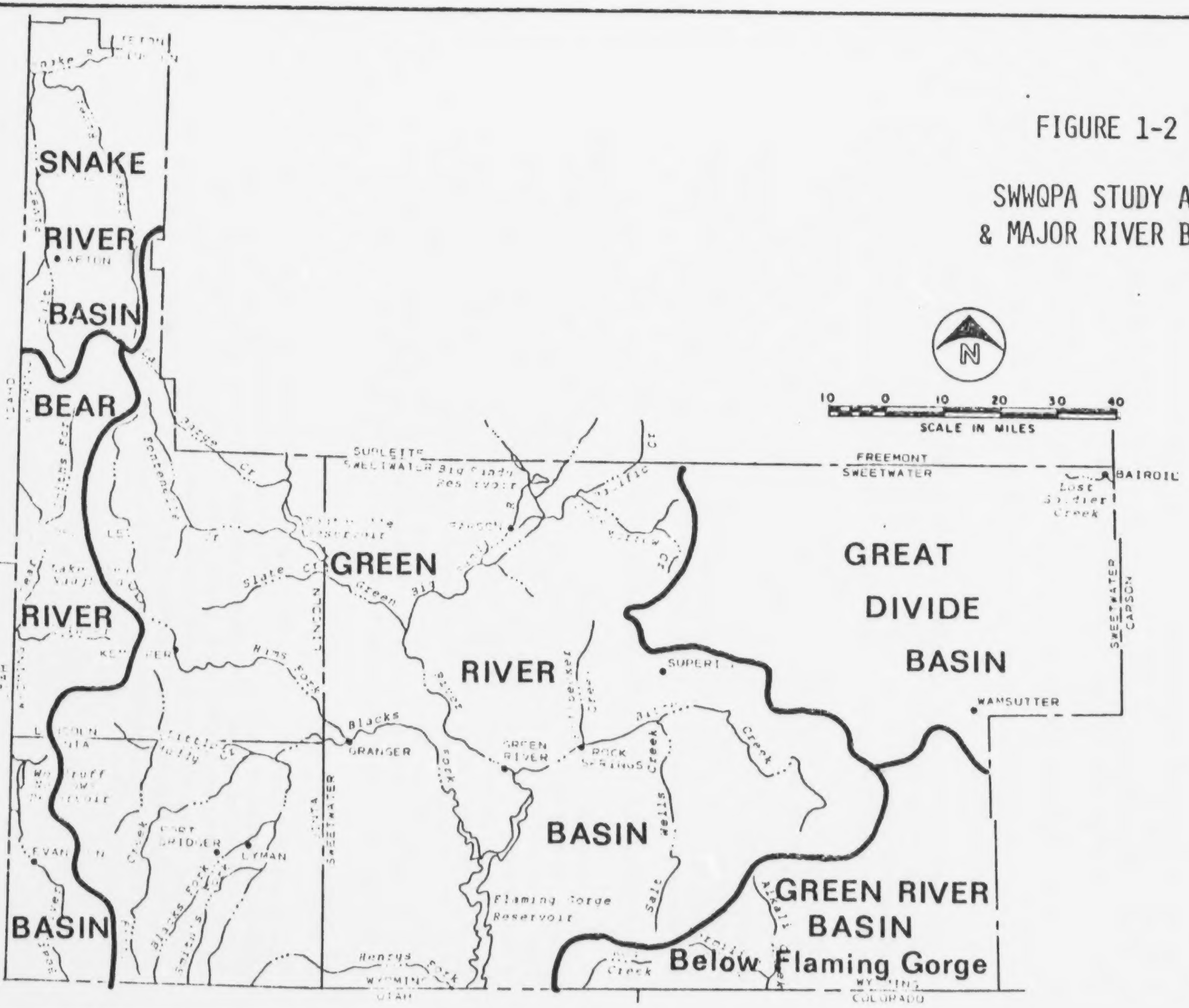
The Southwestern Wyoming 208 area, consisting of the Counties of Sweetwater, Lincoln, and Uinta, is shown on Figure 1-2. Five major river basins have been delineated in the figure. The majority of the area is in the Green River Basin, which is a tributary of the Colorado River system. Along the western edge of the area in Uinta and Lincoln Counties is the Bear River Basin. The Star Valley area in northern Lincoln County is tributary to the Snake River drainage. The remaining two basins are the Great Divide Basin and the Green River Basin below Flaming Gorge Reservoir. The terrain in each of the five major basins is described below in general terms. Because of its size, the Green River Basin has been divided into seven subbasins.

Great Divide Basin

The Great Divide Basin, also known as the Red Desert, is located in northeastern Sweetwater County. It is an internal drainage basin, that is, runoff from rainfall does not leave the basin by surface runoff. The Great Divide Basin is enclosed by the Continental Divide, which separates the drainages to the Atlantic and the Pacific Oceans. The terrain in this basin is high altitude desert country typified by gentle slopes and low and sparse vegetation. Rainfall is less than 8 inches per year.

FIGURE 1-2

SWWQPA STUDY AREA
& MAJOR RIVER BASINS


SNAKE RIVER BASIN
BEAR RIVER BASIN
GREEN RIVER BASIN
GREAT DIVIDE BASIN
GREEN RIVER BASIN Below Flaming Gorge
N
10 0 10 20 30 40
SCALE IN MILES
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
LINCOLN
UINTA
SWEETWATER
CARBON
WYOMING
UTAH
WYOMING
COLORADO
IDAHO
AFTON
KEMMERER
EVANSTON
FORT BRIDGER
LYMAN
GRANGER
GREEN RIVER
ROCK SPRINGS
SUPERIOR
WAMSUTTER
BAIROIL
Lost Soldier Creek
Big Sandy Reservoir
Flaming Gorge Reservoir
Blacks Fork
Hams Fork
Henrys Fork
Slate Cr.
Green
Fontenelle
Salt Wells Creek
Bitter Creek
Alkali Creek
Snake R.

Green River Basin Below Flaming Gorge

In southeastern Sweetwater County, a number of streams rise that drain into Colorado and Utah and join the Green River downstream of Flaming Gorge Reservoir and the Wyoming border. This lower Green River area is very sparsely populated, and the land is highly erosional in form and somewhat similar to that along the edges of the Great Divide Basin.

Bitter Creek Subbasin

The Bitter Creek drainage is along Interstate 80 and along the Union Pacific Railroad just west of the Great Divide Basin. The upstream end of the basin greatly resembles the Great Divide Basin, but downstream the effect of centuries of erosion becomes apparent. Land forms become more abrupt, and the cliffs in the downstream areas indicate that the area was a sea or lakebed during various geological periods. In the vicinity of Rock Springs and downstream toward the Green River, the erosion relief is far more dramatic with formations such as White Mountain dominating the landscape.

Flaming Gorge Reservoir Subbasin

On the Green River beginning from the confluence of Bitter Creek and on downstream is the area of Flaming Gorge. Flaming Gorge is a canyon-like formation located south of the Wyoming-Utah State line on the Green River. It was named by John Wesley Powell and his crew because of the color bands exposed on the rock formations as the gorge was formed by the Green River. A dam has been built in Utah below Flaming Gorge and formed the reservoir that now fills the gorge. The present-day reservoir extends approximately 60 miles from the dam and is formed in the upper part by the arms of the Green River and Blacks Fork, two major tributaries to Flaming Gorge Reservoir. A third major tributary is Henrys Fork, which comes into the reservoir at the Wyoming-Utah State line. Erosion of land forms is prevalent throughout the area, including awesome pinnacles and shear cliffs. Flaming Gorge Reservoir and adjacent lands are administered by the U.S. Forest Service as a National Recreation Area.

Green River Subbasin from Fontenelle Dam to Town of Green River

The Green River provides a contrast to the largely desert-type surrounding country. The river itself stands out from the otherwise monotonous desert terrain. The change in vegetation is striking with the willows and cottonwoods along the river's banks providing a dramatic contrast to the sagebrush and grasses of the desert areas further away from the water. Today, 35 miles of the river are contained in the Seedskadee National Wildlife Refuge, which was established to replace nesting grounds inundated by Fontenelle Reservoir further upstream. In the refuge area, numerous canals have been constructed to flood wide areas in order to create the proper marshy conditions desirable for nesting ducks and geese. The refuge lies above and below the confluence of the Green River with the Big Sandy River.

Fontenelle Reservoir and Upstream Subbasin

Near the line between Sweetwater and Lincoln Counties is Fontenelle Dam, which forms the reservoir that extends on up into Lincoln County. Upstream of the reservoir, the Green River extends down from Sublette County, which is outside the study area. Evidences of a broad erosional plain are prevalent throughout this Upper Green River area and in the reach near Fontenelle. The plain appears more narrow than further downstream. Along the stream, there are hay pastures as opposed to the wildlife refuge downstream, and the land use activities are more related to those of the Upper Green River Basin in Sublette County than to those in Sweetwater County.

Big Sandy River Subbasin

The Big Sandy River subbasin is located in north central Sweetwater County. It is largely desert country with irrigated agriculture in the Eden Valley near Farson and Eden. The terrain is moderately rolling.

Hams Fork Subbasin

Hams Fork is a tributary of Blacks Fork and rises in central Lincoln County. The communities of Kemmerer, Diamondville and Frontier are along Hams Fork. Extensive coal deposits have been developed in the basin. The terrain has narrower eroded valleys than are found further downstream.

Bridger Valley Subbasin

Most of Uinta County is contained in the area known as Bridger Valley. The valley is named after Jim Bridger, an early scout for whom Fort Bridger is also named. Bridger Valley generally has a broad rolling terrain with numerous drainages flowing north through it. It is well suited for agriculture, which has been a major economic force in the area since the late 1800's. The streams in Bridger Valley generally rise in Utah in the Uinta Mountains to the south. The southern part of the valley is characterized as being moderately forested as compared to the northeastern part of the valley, which is largely desert country with erosional forms.

Bear River Basin

The Bear River meanders in and out of the 208 planning area. It rises in Utah, enters the planning area in southwestern Uinta County, flows into Utah again in the northwestern part of Uinta County, reenters the area in southwestern Lincoln County, and exits again north of Cokeville in central Lincoln County, this time into Idaho. Eventually the Bear River swings west and then south and is diverted to Bear Lake in Utah. The Bear River Valley is narrow to moderately wide and seems to have been formed by fluvial deposits. Agriculture is practiced to a large extent along the Bear River, and the flat alluvial lands are easily irrigated.

Star Valley Area

In northern Lincoln County, the Star Valley is formed between some low hills in Idaho and the Salt River Range in Wyoming. Two streams--Greys River and the Salt River--rise in this area and flow north to meet the Snake River. Greys River on the east side of the Salt River Range is hardly developed at all, but the alluvial plains of the Salt River have been largely developed for agriculture. Dairying is a major activity in this area.

CLIMATE

Most of the study area is characterized as having a high plains, arid type climate with low rainfall, and a tendency toward moderate to high winds. Rainfall distribution in the area is shown on Figure 1-3.

The average monthly precipitation throughout the annual cycle is given on Figure 1-4 for Rock Springs. The range of temperatures in Rock Springs on an annual cycle is shown on Figure 1-5.

HISTORY OF THE AREA

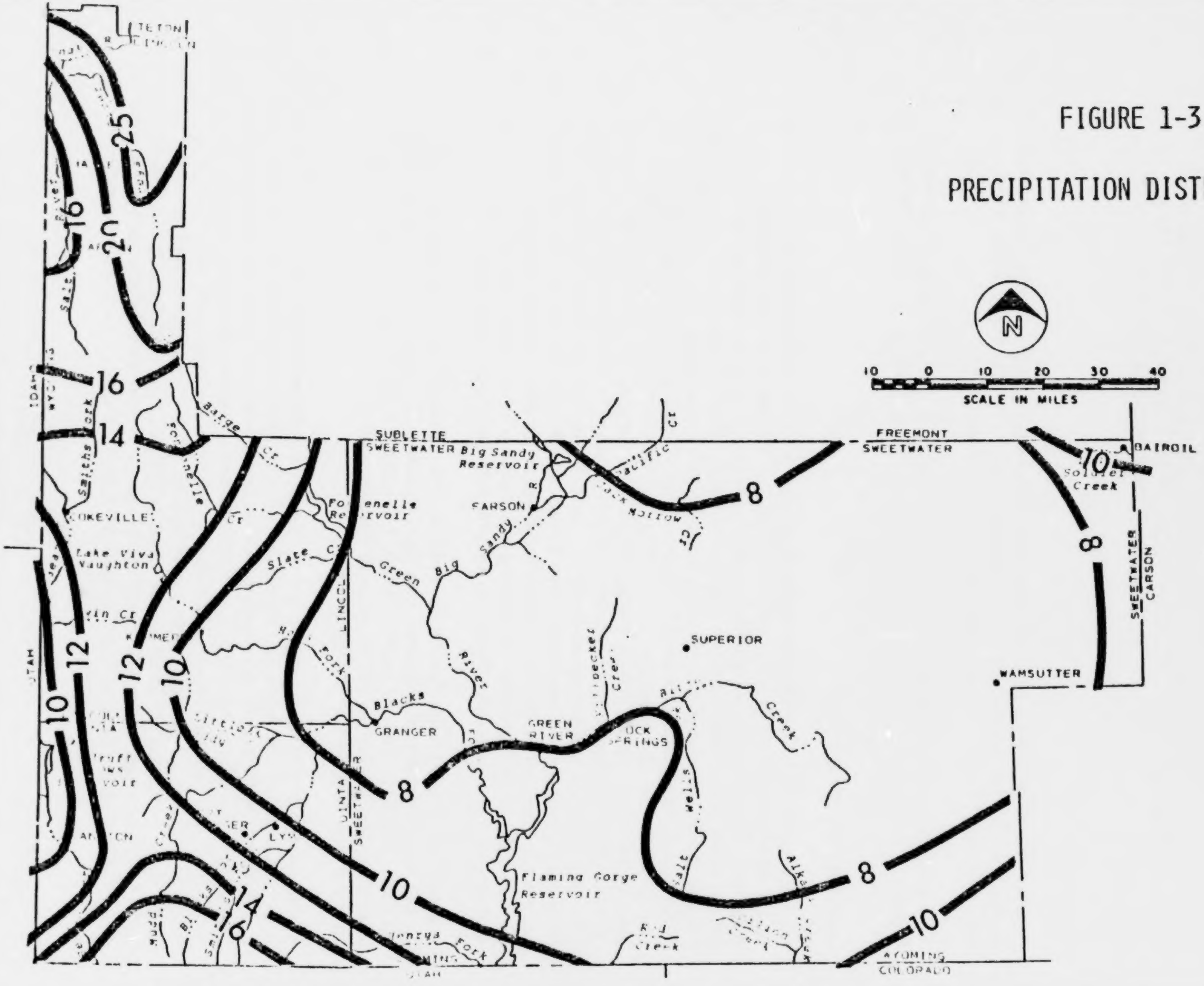
Development in Southwestern Wyoming was largely influenced by the availability of transportation through the area, particularly in the southern portion. The Mormon, California, and Oregon Trails all passed through Sweetwater and Unita Counties after crossing South Pass. Later, the Union Pacific Railroad route was developed through Sweetwater and Uinta Counties. This route traversed the entire length of Southwestern Wyoming because of the opportunity to cross the Continental Divide in the Great Divide Basin and to thereby avoid higher mountain passes further south or north. Most of the communities in Sweetwater and Uinta Counties have developed along the railroad or in association with it. Coal mined in the Rock Springs area was used by the railroad, and Green River and Evanston are division points for the Union Pacific. Additionally, Interstate 80 now passes through the area, roughly following the route of the Union Pacific. Air service in Southwestern Wyoming is provided at Rock Springs.

Aside from the transportation corridors, the second most important factor in the development of the area was agriculture. Bridger Valley, Bear River Valley, and Star Valley have already been mentioned as prime agricultural areas. Eden Valley in north central Sweetwater County has been developed through the Big Sandy irrigation project.

Minerals have played a large role in the area's development as well. The coal deposits in the Rock Spring-Green River area have been mined since the railroad came through, and coal mining using both surface and subterranean methods is a cyclic industry. In western Sweetwater County is located the trona patch. The mining and processing of this mineral, which is largely used in the manufacture of glass and is also used to produce baking soda, is a major industry in Sweetwater County. Coal deposits in Lincoln County around Kemmerer have also been developed. Power plants are located at or near the coal deposits in both Sweetwater and Lincoln Counties. Other

FIGURE 1-3

PRECIPITATION DISTRIBUTION


10 0 10 20 30 40
SCALE IN MILES
N
TETON
LINCOLN
IDAHO
WYOMING
UTAH
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
CARSON
LINCOLN
UINTA
SWEETWATER
WYOMING
COLORADO
BAIROIL
Soldier Creek
WAMSUTTER
SUPERIOR
FARSON
Big Sandy Reservoir
Fontenelle Reservoir
COKEVILLE
Lake Viva Vaughton
KEMMERER
GRANGER
Blacks
GREEN RIVER
ROCK SPRINGS
Flaming Gorge Reservoir
Green
Big Sandy
River
Slate Cr
Hams Fork
Barge Cr
Smiths Fork
Salt River
Pacific
Killpecker Creek
Bitter Creek
Salt Wells
Alkali Creek
Red Creek
Henrys Fork
LYMAN
25
20
16
16
14
12
12
10
10
10
8
8
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14
16

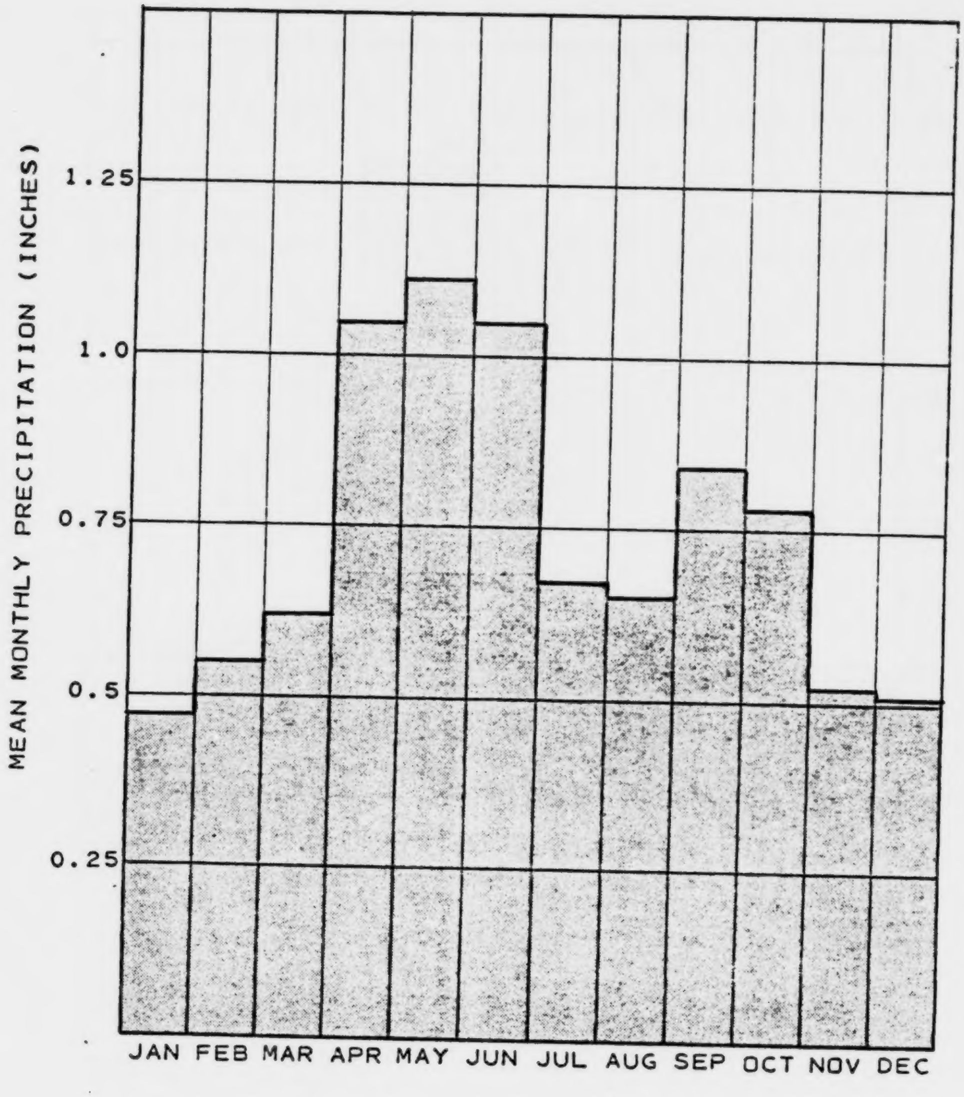

FIGURE 1-4

MEAN MONTHLY
PRECIPITATION,
ROCK SPRINGS,
1951-1974

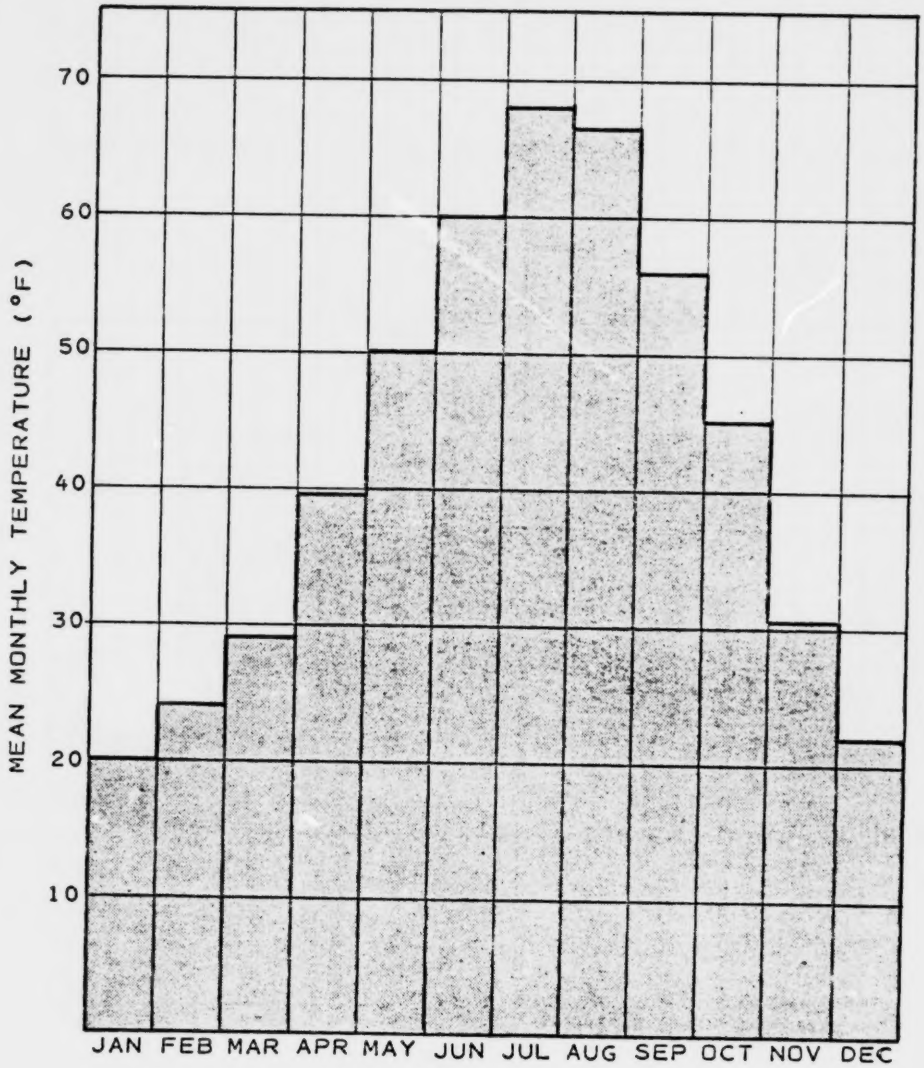

FIGURE 1-5

MEAN MONTHLY
TEMPERATURES,
ROCK SPRINGS,
1951-1974

minerals, such as uranium and oil shale, have been discovered throughout the area. These minerals are being mined or are slated to be mined.

FUTURE GROWTH OF THE AREA

Tremendous future expansion and growth through the mineral industry and energy developments is forecast for Sweetwater and Unita Counties and much of Lincoln County. The coal deposits in Southwestern Wyoming are expected to be developed in response to the nation's search for additional energy sources.

Two scenarios have been developed during this study to describe potential future conditions and their related potential water quality impacts. One of these was titled the energy export scenario and the other the coal export scenario. The energy export descriptive assumed that the coal would be mined in the area and used to generate power within the area, whereas the coal export scenario assumed that the coal would be mined and shipped to power plants elsewhere.

Whatever the future development pattern, it is likely to cause large increases in population for existing communities. Rock Springs and Green River already experienced tremendous boom growth in the early 1970's. Growth is also already being experienced in Evanston; Kemmerer; the Bridger Valley communities of Lyman, Fort Bridger, and Mountain View; and many other smaller communities throughout the study area. It is largely this potential for future growth and development as a result of the energy and minerals industry that the Governor designated this area as a 208 study area. The need was recognized for the development of a plan to manage water quality in view of the expected tremendous expansion.

MOST PRESSING WATER CONCERNS

In 1977 perhaps the most pressing water concern has been the lack of sufficient quantities of water. During this year the area has experienced a drought period, and streamflows have been extremely low as have the winter snowpacks. The low flow conditions have magnified some water quality problems.

As found in this study, the most significant water quality problems to the area are those associated with failing septic tank systems, eutrophication in the reservoirs, sediments and salinity. The problems of eutrophication and sediments are closely related, because eutrophication in this area is largely controlled by reductions of phosphorus, which is mainly carried into streams with sediment.

Phosphorus serves as a nutrient for algae and other aquatic plants. Algae blooms, as currently being experienced in the upper parts of Flaming Gorge Reservoir, in Woodruff Narrows Reservoir, and to some extent in other reservoirs in the area, are largely a nuisance for such recreational use of the waters as boating, swimming, fishing, or water skiing. Small amounts of algae are fairly well dispersed through the water, and as their concentration increases, they become apparent through a green murky appearance of the water. As additional phosphorus is present, other forms of algae, the blue-greens, can develop, and these tend to clump together in mats that float on or near the surface.

Salinity is a concern for two reasons. First, there is a need to control salinity throughout the Colorado River Basin as a result of interstate and international agreements. Second, water users in the area are concerned because of the higher costs associated with the use of saline water for industrial and municipal purposes.

This study focuses on septic tanks, salinity, eutrophication, and erosion. The first half of this report gives a more detailed description of the water quality situation and the water quality criteria used to measure what are desirable levels for various pollutants. The description includes not only parameters associated with the major problems mentioned above, but many other water quality parameters also.

Chapter 2
WATER QUALITY CRITERIA

The establishment of water quality criteria is one of the initial steps toward management of water resources and control of water quality problems. The water quality criteria developed in this section of the report represent water quality goals for the study area. They are not to be viewed as water quality standards. Criteria are valuable in the identification of water quality problems; standards are the legal values established for controlling a problem. Standards for the study area have been adopted by the State of Wyoming in the past. The decision to recommend that certain water quality criteria be adopted as water quality standards is made in Chapter 11 only after a thorough investigation of the environmental, economic, and health impacts of the decision.

WATER USES IN THE STUDY AREA

A use-based approach to water quality management has been selected over a quality-based approach for two reasons. First, the use-based approach presents fewer restrictions on water resources development, because it permits water quality degradation to the level specified by the water quality criteria. It is recommended that water resources development options be kept open at this time because of the uncertainty of future water demands on the area's water resources. Second, a use-based approach is consistent with the approach of the State of Wyoming towards water quality. According to the Wyoming Water Quality Rules and Regulations, (1) "The goal of the water pollution control program is to maintain the best possible quality of water commensurate with use."

Nine types of water uses, each of which requires a different quality of water, have been defined in the study area, as described on Table 2-1. Nine sets of water quality criteria, presented later in this chapter, have been developed in terms of the quality needed to accomodate these uses.

Existing and projected uses, based on the nine use types, have been generated on a reach-by-reach basis in order to reduce the 16,000-square-mile study area to reasonably sized water quality management units. A schematic diagram of the 52 reaches delineated in the study area is shown on Figure 2-1. The schematic diagram has taken some liberties with reality in order to improve the layout of the figure. A few reaches have been oriented differently, such as the two upper reaches of the Blacks Fork, in which the river

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(1) These Rules and Regulations also have a quality-based provision which states that "waters whose existing quality is better than the established standards...will be maintained at high quality" unless it is demonstrated that a change in water quality "is justifiable to provide necessary economic or social development."

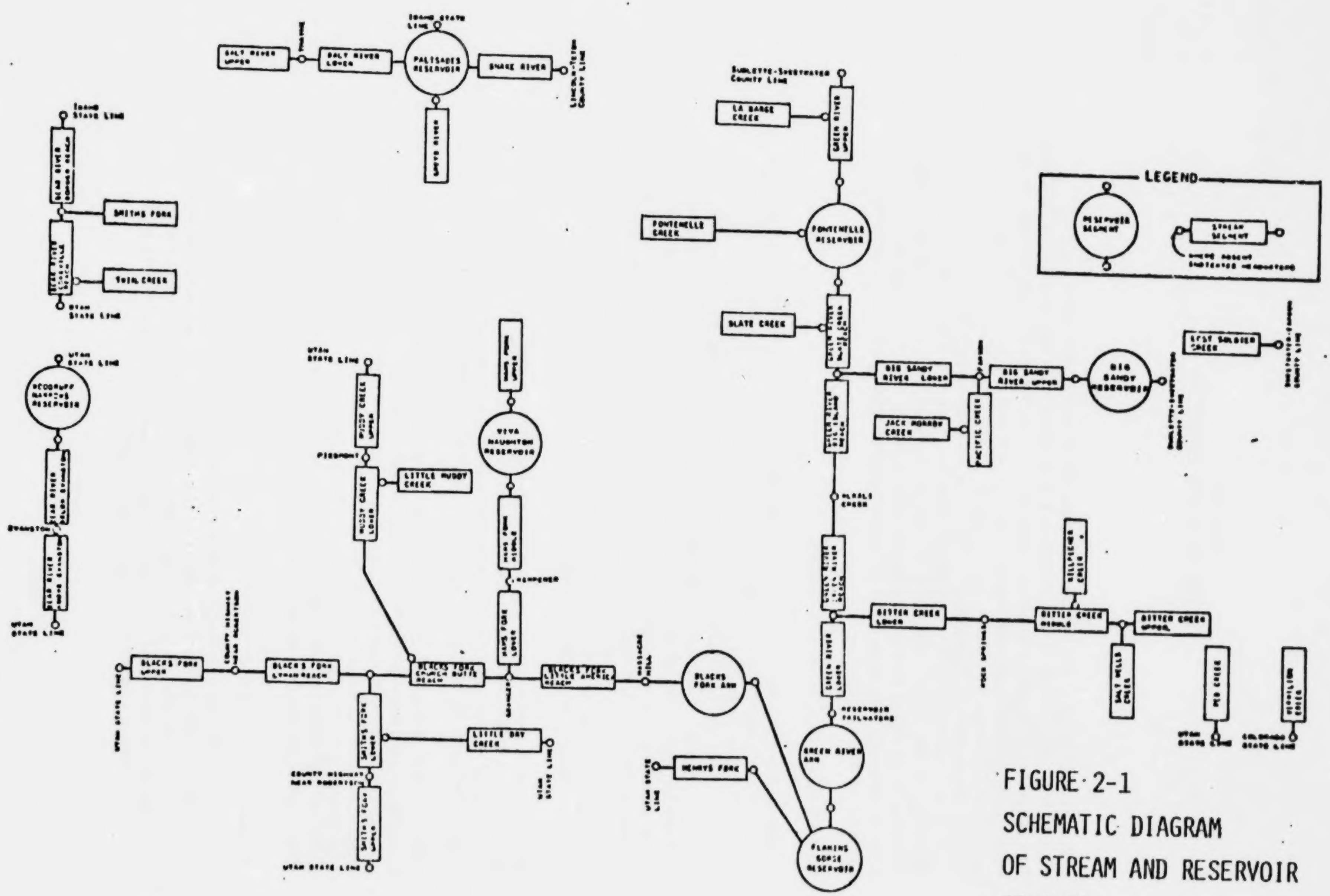
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
SALT RIVER UPPER
SALT RIVER LOWER
PALISADES RESERVOIR
IDAHO STATE LINE
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
IDAHO STATE LINE
BEAR RIVER BORDER REACH
SMITHS FORK
BEAR RIVER COKEVILLE REACH
TWIN CREEK
UTAH STATE LINE
UTAH STATE LINE
WOODRUFF NARROWS RESERVOIR
BEAR RIVER BELOW EVANSTON
EVANSTON
BEAR RIVER ABOVE EVANSTON
UTAH STATE LINE
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER UPPER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK REACH
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-FREMONT COUNTY LINE
GREEN RIVER BIG SANDY REACH
JACK MORROW CREEK
PACIFIC CREEK
ALKALI CREEK
GREEN RIVER BITTER CREEK REACH
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
VERMILLION CREEK
UTAH STATE LINE
COLORADO STATE LINE
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
UTAH STATE LINE
UTAH STATE LINE
MUDDY CREEK UPPER
PIEDMONT
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
HAMS FORK UPPER
VIVA NAUGHTON RESERVOIR
HAMS FORK MIDDLE
KEMMERER
HAMS FORK LOWER
UTAH STATE LINE
BLACKS FORK UPPER
COUNTY HIGHWAY NEAR MOUNTAIN VIEW
BLACKS FORK LYMAN REACH
BLACKS FORK CHURCH BUTTE REACH
GRANGER
BLACKS FORK LITTLE AMERICA REACH
MASSACRE HILL
BLACKS FORK ARM
SMITHS FORK LOWER
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
LITTLE DRY CREEK
UTAH STATE LINE

FIGURE 2-1
SCHEMATIC DIAGRAM
OF STREAM AND RESERVOIR
REACHES

Table 2-1

WATER USE DEFINITIONS

Water Use	Definition	Basis for Establishing Water Quality Criteria
Secondary Contact Recreation	Water with which the human body may come in contact, but normally not to the point of complete submergence. Such activities include wading, fishing, boating, and hiking.	The water must be aesthetically acceptable for the recreation activities. Ingestion of small amounts of water and whole body submergence are normally not expected. Propagation of fish is not included.
Primary Contact Recreation	Water in which the human body may be completely submerged with prolonged and intimate contact. Such activities include swimming, water skiing, and floating.	The water must be aesthetically acceptable for the recreation activities and should not cause skin or eye irritation. Ingestion of small amounts of water should not cause illness.
Stream Aesthetics	Streams which have scenic value.	Surface water must be virtually free from substances which impair the visual character of the water body or cause unpleasant odors.
Reservoir and Lake Aesthetics	Reservoirs and lakes which have scenic value.	Surface water must be virtually free from substances which impair the visual character of the water body or cause unpleasant odors. The major concern is substances and conditions which produce undesirable aquatic growth.
Industrial Water Supply	Raw water diverted from streams or lakes used by various industries for process purposes or for removal of heat after water treatment by the individual industries.	The major industrial uses of water are assumed to be for coal gasification, petroleum refining, trona processing, and power generation. Criteria are based on the use of raw water diverted to a storage basin and used for process water or recirculating cooling systems.
Agricultural Irrigation	Water used for the irrigation of crops.	Irrigation water quality is based on the requirements of alfalfa. Waters are assumed to be used continuously during the growing season on all soil. Soil conditions which would further limit water quality are not specified.
Wildlife and Livestock Watering	Water used by wildlife (excluding fish) and livestock for consumption.	Water quality must ensure short-term and long-term survival of wildlife and livestock, including waterfowl, but excluding fish. Substances which will taint meat or milk are also limited.
Public Water Supply	Raw water used for drinking and other domestic or municipal purposes AFTER conventional treatment.	Surface water must be potable after conventional water treatment which is assumed to be (1) coagulation, (2) sedimentation, (3) rapid sand filtration, and (4) chlorine disinfection. Substances which interfere with treatment processes should be limited. Toxic substances (both acute and chronic) not removed by conventional water treatment must meet requirements for potable standards.
Fishery	Water used to support and propagate a cold or warm water fishery.	Water quality must support a rainbow trout fishery. Substances which taint fish are also limited.

actually flows south to north, but which the diagram shows to be oriented west-east. Also, all reaches are the same size in the diagram, although in reality they vary greatly in stream length and watershed area. However, all upstream reaches are shown as upstream in the diagram, and all downstream reaches are shown as downstream.

The uses identified for each stream reach are presented on Table 2-2. This list includes both existing and projected water uses, and represents the goal for the area. A preliminary list of the existing and projected water uses in each reach was presented in the *Interim Clean Water Report for Southwestern Wyoming*, dated December 1976. Recommendations on existing use corrections have been received from local citizens, the Rock Springs District Office of the Bureau of Land Management, the Green River and Pinedale Offices of the Wyoming Game and Fish Commission, the Ashley National Forest District of the U.S. Forest Service, the Wyoming Department of Environmental Quality, the Wyoming State Engineer's Office, and the Department of Environmental Sanitation for Sweetwater County. These recommended changes have been reviewed and incorporated into a revised set of uses for each reach which is presented on Table 2-2.

The revised set of uses includes all the existing surface water uses in the study area. It also reflects planned surface water uses by the State of Wyoming, industries, and local citizens. The planned uses by Wyoming concern primary contact recreation and fisheries in the study area and are listed in *Stream Classifications in Wyoming* (dated October 1, 1976). Planned industrial uses have been obtained from the Southwest Wyoming Industrial Association (SWIA). Planned uses by local citizens were learned in public meetings held during January 1977.

Use of ground water in the study area is small compared to use of surface water. Areas of major ground water use are shown on Figure 2-2. Ground water uses include domestic and public water supply, livestock watering, industrial water supply, and agricultural irrigation.

COMPLIANCE WITH NATIONAL GOAL

The national goal toward which the 208 program is directed is stated in Section 101(a)(2) of the 1972 Clean Water Act:

> "It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983."

The water quality goal generated in this study, as presented on Table 2-2, appears to fall short of the national goal in two respects. Thirty-eight reaches are not designated for primary contact recreation, or recreation "in the water," and six reaches are not designated as fisheries.

These differences are permitted if it can be proven that primary contact recreation and fishing are not attainable in those reaches for one or more of the reasons stated below:

Table 2-2

STREAM REACHES AND WATER USES[1]

BASIN	RIVER	REACH	Reach Number	REACH BOUNDARIES	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Reservoir and Lake Aesthetics	Industrial Water Supply	Agricultural Irrigation	Wildlife and Livestock Watering	Public Water Supply	Fishery[2]
Snake River	Snake River	Snake River	1	Lincoln-Teton County Line to Palisades Reservoir	x	x	x				x		x
	Greys River	Greys River	2	Headwaters to Snake River	x		x				x		x
	Salt River	Upper	3	Headwaters to Thayne	x		x			x	x		x
		Lower	4	Thayne to Backwaters of Palisades Reservoir	x		x			x	x		x
		Palisades Reservoir	5	Backwaters of Palisades Reservoir to Idaho State Line	x	x		x			x		x
Bear River	Bear River	Above Evanston	6	Utah State Line to Evanston	x		x		x	x	x	x	x
		Below Evanston	7	Evanston to Backwaters of Woodruff Narrows Reservoir	x		x			x	x		x
		Woodruff Narrows Reservoir	8	Backwaters of Woodruff Narrows Reservoir to Utah State Line	x	x		x		x	x		x
		Cokeville Reach	9	Utah State Line to Smiths Fork	x		x		x	x	x		x
		Border Reach	10	Smiths Fork to Idaho State Line	x		x		x	x	x		x
	Twin Creek	Twin Creek	11	Headwaters to Bear River	x		x		x		x		x[3]
	Smiths Fork	Smiths Fork	12	Headwaters to Bear River	x		x			x	x		x
Green River	Green River	Upper	13	Sublette-Sweetwater County Line to Backwaters of Fontenelle Reservoir	x	x	x			x	x		x
		Fontenelle Reservoir	14	Backwaters to Dam, Fontenelle Reservoir	x	x		x	x	x	x	x	x
		Slate Creek Reach	15	Fontenelle Reservoir Dam to Big Sandy River	x	x	x		x	x	x	x	x
		Big Island Reach	16	Big Sandy River to Alkali Creek	x	x	x		x	x	x		x
		Green River Reach	17	Alkali Creek to Bitter Creek	x	x	x		x	x	x	x	x
		Lower	18	Bitter Creek to Flaming Gorge Reservoir Backwaters	x	x	x		x	x	x		x
		Green River Arm, Flaming Gorge Reservoir	19	Flaming Gorge Reservoir Backwaters to Confluence with Blacks Fork Arm	x	x		x	x		x	x	x
		Flaming Gorge Reservoir	20	Confluence of Green River and Blacks Fork Arm to Utah State Line	x	x		x			x	x	x
	La Barge Creek	La Barge Creek	21	Headwaters to Green River	x		x			x	x		x
	Fontenelle Creek	Fontenelle Creek	22	Headwaters to Fontenelle Reservoir	x		x			x	x		x
	Slate Creek	Slate Creek	23	Headwaters to Green River	x		x			x	x		x
	Big Sandy River	Big Sandy Reservoir	24	Backwaters to Dam, Big Sandy Reservoir	x	x		x			x		x
		Upper	25	Big Sandy Reservoir Dam to Pacific Creek near Farson	x		x			x	x		x
		Lower	26	Pacific Creek near Farson to Green River	x		x				x		x
	Pacific Creek	Pacific Creek	27	Headwaters to Big Sandy River	x		x			x	x		x
	Jack Morrow Creek	Jack Morrow Creek	28	Headwaters to Pacific Creek	x		x				x		
	Bitter Creek	Upper	29	Headwaters to Salt Wells Creek	x		x			x	x		x[3]
		Middle	30	Salt Wells Creek to Rock Springs	x		x				x		

Table 2-2 (Continued)

STREAM REACHES AND WATER USES(1)

BASIN	RIVER	REACH	Reach Number	REACH BOUNDARIES	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Reservoir and Lake Aesthetics	Industrial Water Supply	Agricultural Irrigation	Wildlife and Livestock Watering	Public Water Supply	Fishery(2)
Green River (Continued)													
		Lower	31	Rock Springs to Green River	x		x				x		
	Salt Wells Creek	Salt Wells Creek	32	Headwaters to Bitter Creek	x		x				x		
	Killpecker Creek	Killpecker Creek	33	Headwaters to Bitter Creek	x		x				x		
	Blacks Fork	Upper	34	Utah State Line to County Hwy. near Robertson	x		x		x	x	x		x
		Lyman Reach	35	County Highway near Robertson to Smiths Fork	x		x			x	x	x	x
		Church Butte Reach	36	Smiths Fork to Hams Fork near Granger	x		x			x	x		x(4)
		Little America Reach	37	Hams Fork near Granger to Massacre Hill	x		x			x	x		x
		Blacks Fork Arm, Flaming Gorge Reservoir	38	Massacre Hill to Confluence with Green River Arm	x	x		x	x	x	x		x
	Smiths Fork	Upper	39	Utah State Line to County Hwy. near Robertson	x		x			x	x	x	x
		Lower	40	County Highway near Robertson to Blacks Fork	x		x		x	x	x		x
	Little Dry Creek	Little Dry Creek	41	Utah State Line to Smiths Fork	x		x			x	x		x
	Muddy Creek	Upper	42	Utah State Line to Piedmont	x		x			x	x		x
		Lower	43	Piedmont to Blacks Fork	x		x				x		x
	Little Muddy Creek	Little Muddy Creek	44	Headwaters to Muddy Creek	x		x				x		x(3)
	Hams Fork	Upper	45	Headwaters to Viva Naughton Reservoir Backwaters	x		x			x	x		x
		Viva Naughton Reservoir	46	Backwaters to Dam, Viva Naughton Reservoir	x	x		x			x		x
		Middle	47	Viva Naughton Reservoir Dam to below Kemmerer	x		x		x	x	x	x	x
		Lower	48	Below Kemmerer to Blacks Fork	x		x		x	x	x	x	x
	Henrys Fork	Henrys Fork	49	Utah State Line to Flaming Gorge Reservoir	x		x			x	x		x
Green River Below Flaming Gorge	Red Creek	Red Creek	50	Headwaters to Utah State Line	x		x				x		x
	Vermilion Creek	Vermilion Creek	51	Headwaters to Colorado State Line	x		x		x	x	x		x
Great Divide Basin	Lost Soldier Creek	Lost Soldier Creek	52	Headwaters to Sweetwater-Carbon County Line	x		x				x		

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(1) Water uses are defined on Table 2-1.
(2) All are cold water, game fisheries unless otherwise noted.
(3) Cold water, nongame fishery.
(4) Warm water, nongame fishery.

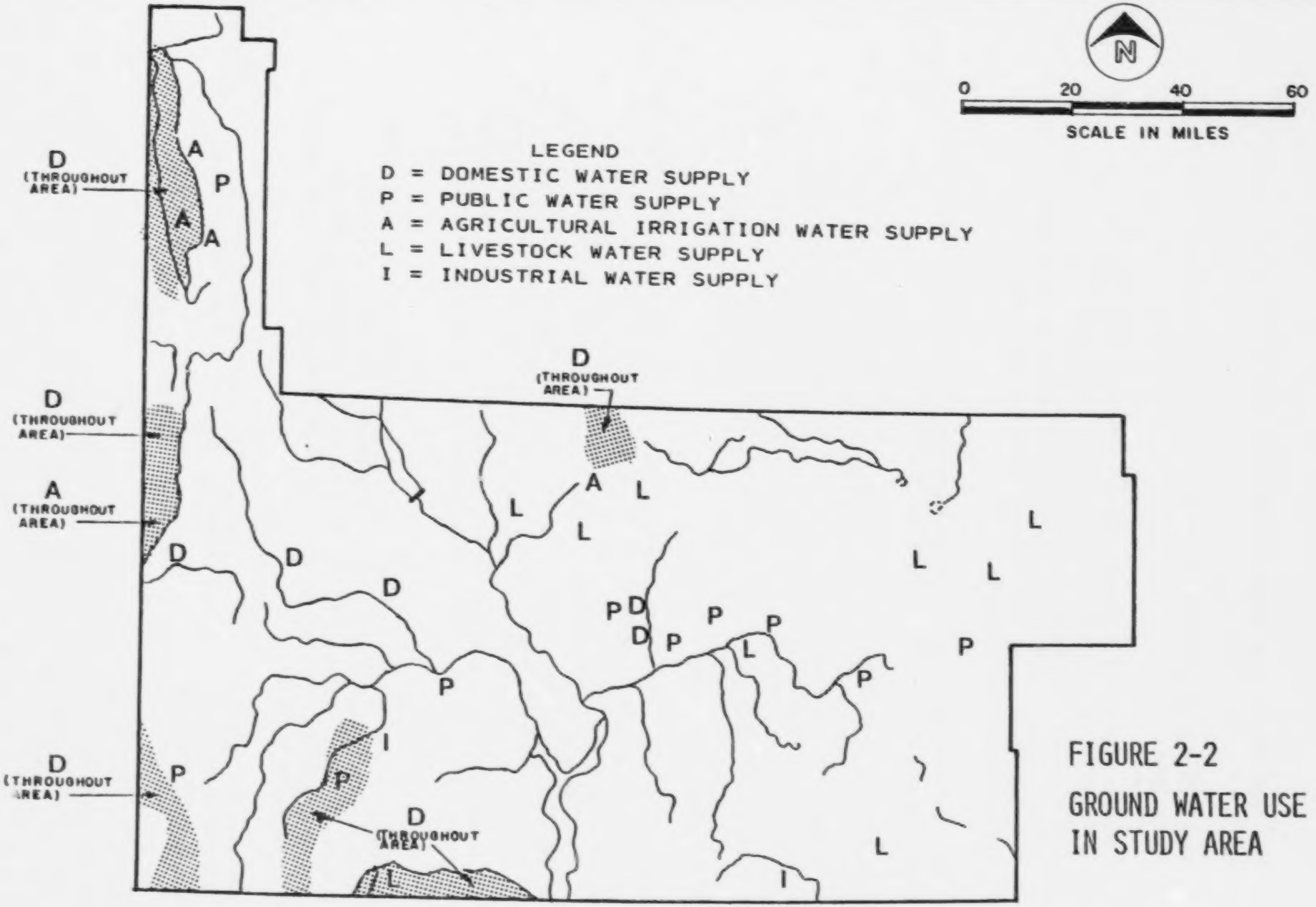
LEGEND
D = DOMESTIC WATER SUPPLY
P = PUBLIC WATER SUPPLY
A = AGRICULTURAL IRRIGATION WATER SUPPLY
L = LIVESTOCK WATER SUPPLY
I = INDUSTRIAL WATER SUPPLY
N
0
20
40
60
SCALE IN MILES
D (THROUGHOUT AREA)
D (THROUGHOUT AREA)
A (THROUGHOUT AREA)
D (THROUGHOUT AREA)
D (THROUGHOUT AREA)
D (THROUGHOUT AREA)
A
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FIGURE 2-2
GROUND WATER USE
IN STUDY AREA

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- The use cannot be attained because of natural background conditions
- The use cannot be attained because of irretrievable man-induced conditions
- The use cannot be attained because the imposition of controls above or in addition to the technology-based requirements of BATEA (Best Available Technology Economically Available) and BPWTT (Best Practicable Wastewater Treatment Technology) would be required and would result in a substantial and widespread adverse economic and social impact.

As shown below, fisheries and primary contact recreation cannot exist in many reaches because of natural background conditions.

Out of the six reaches not designated in Table 2-2 as fisheries(1), the Wyoming Game and Fish Department has classified four as not having the hydrologic potential to support fish. The other two reaches, Jack Morrow Creek and Salt Wells Creek are not classified, but are intermittent streams and assumed to have insufficient flow to support fish. Therefore, with respect to fishery, the goal generated in this study appears to be in compliance with the national goal. Low flow seems to prevent the establishment of a fishery in the six reaches.

Two natural background conditions, low flow and low temperatures, discourage primary contact recreation in many of the 38 reaches which have not been designated for that use in Table 2-2. As shown on Figure 1-3, most of the study area is extremely arid. Many streams have little or no flow during the summer months. Only the larger streams are capable of accomodating primary contact recreational uses such as swimming and floating. Rivers with adequate summer flows include Snake River, Greys River, Salt River, Bear River, Green River, Big Sandy River, Blacks Fork, Smiths Fork, Hams Fork and Henrys Fork. Streams with inadequate summer flows are listed on Table 2-3.

Some of the streams with adequate flows have summer water temperatures too low to permit comfortable primary contact recreation. Reaches in which summer temperatures average less than 11.5°C (52°F) are designated on Table 2-3. Low temperatures are assumed to make primary contact recreation unattainable in these reaches.

After accounting for low flows and low temperatures, only eight reaches show primary contact recreation as a possible, but not existing or desired, use. These reaches are:

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(1) The six reaches are Jack Morrow Creek (#28), Middle Bitter Creek (#30), Lower Bitter Creek (#31), Salt Wells Creek (#32), Killpecker Creek (#33), and Lost Soldier Creek (#52).

Table 2-3

REACH DESIGNATIONS FOR PRIMARY CONTACT RECREATION

Reach	Reach Number	Natural Background Condition Preventing Use		Primary Contact Recreation Possible(1)	Primary Contact Recreation Existing or Desired(2)
		Low Flow	Low Temperature		
Snake River	1			x	x
Greys River	2		x		
Salt River	3 & 4		x		
Palisades Reservoir	5			x	x
Bear River Head to Smiths Fork	6,7 & 9		x		
Woodruff Narrows Reservoir	8			x	x
Bear River, Border Reach	10			x	
Twin Creek	11	x			
Smiths Fork	12	x			
Green River	13 thru 18			x	x
Flaming Gorge Reservoir	19,20 & 38			x	x
La Barge Creek	21	x			
Fontenelle Creek	22	x			
Slate Creek	23	x			
Big Sandy Reservoir	24			x	x
Big Sandy River	25 & 26			x	
Pacific Creek	27	x	x		
Jack Morrow Creek	28	x	x		
Bitter Creek	29,30 & 31	x			
Salt Wells Creek	32	x			
Killpecker Creek	33	x			
Blacks Fork, Upper	34		x		
Blacks Fork, Lyman to L. America	35,36 & 37			x	
Smiths Fork	39 & 40		x		
Little Dry Creek	41	x			
Muddy Creek	42 & 43	x			
Little Muddy Creek	44	x			
Hams Fork, Upper	45		x		
Viva Naughton Reservoir	46			x	x
Hams Fork, Middle & Lower	47 & 48			x	
Henry's Fork	49		x		
Red Creek	50	x			
Vermilion Creek	51	x			
Lost Soldier Creek	52	x			

---

(1) This column represents use designations under the national goal.
(2) This column is from Table 2-2 and represents use designations under the locally generated goal.

- Bear River, Border Reach
- Big Sandy River, Upper and Lower Reaches
- Blacks Fork, Lyman, Church Butte, and Little America Reaches
- Hams Fork, Middle and Lower Reaches

The national water quality goal would require water quality to accomodate primary contact recreation in these reaches, while the locally generated 208 goal would require water quality to accomodate only secondary contact recreation. Later in this report, two alternative programs will be developed to attain the national goal and the local 208 goal. The program associated with the national goal may have a higher cost because of the higher water quality required by it.

EXISTING WATER QUALITY STANDARDS

Water quality in the study area is presently regulated by the National Interim Primary Drinking Water Regulations (September 1976), State of Wyoming Water Quality Standards, and discharge permits issued by Wyoming under the National Pollutants Discharge Elimination System (NPDES). The State of Wyoming Water Quality Standards are instream standards which apply to surface waters only, while the Drinking Water Regulations apply to both surface water and ground water. Discharge permits are issued for municipal and industrial dischargers and require best practicable treatment and compliance with Wyoming Water Quality Standards.

The State of Wyoming standards are based on the protection of game and nongame fisheries. Surface waters in Wyoming have been divided into three classes related to the capability of a stream to support a fishery. These classes are defined on Table 2-4. Classifications for major streams in the study area are shown on Figure 2-3. Water quality standards associated with each class are presented on Table 2-5. Many streams in the study area are designated by the Department of Environmental Quality (DEQ) as Class I, to which the strictest set of water quality standards apply.

The Colorado Salinity Forum has proposed a policy for implementation of Colorado River Salinity Standards through the NPDES Permit Program. This policy calls for salinity limits on point source discharges of no more than 379 mg/l and 1 ton per day or 350 tons per year, whichever is greater. The State of Wyoming has adopted this policy; however, these salinity standards are not used in the permit program in the study area at the present time.

DEVELOPMENT OF THE CRITERIA

The staff of SWWQPA and their consultants have developed a set of water quality criteria with assistance from DEQ with which to judge water quality. The criteria primarily incorporate three different sets of water quality criteria or standards--the most recent (September 1976) National Interim Primary Drinking Water Regulations, the latest (1975) EPA *Quality Criteria for Water*, and the existing State Water Quality Standards with modifications

Table 2-4

WYOMING SURFACE WATERS CLASSIFICATION

CLASS I	Waters determined to be presently supporting game fish or have the hydrologic and natural water quality to support game fish.
CLASS II	Waters determined to be presently supporting nongame fish or have the hydrologic and natural water quality potential to support nongame fish.
CLASS III	Waters determined as not having the hydrologic or natural water quality potential to support fish.

Reference: *Wyoming Water Quality Rules and Regulations, 1974.* Aug. 1974, Wyoming Department of Environmental Quality.

REFERENCE: WYOMING WATER POLLUTION CONTROL PROGRAM
PLAN FOR FISCAL YEAR 1978
OCTOBER 1977
WYOMING DEPARTMENT OF
ENVIRONMENTAL QUALITY

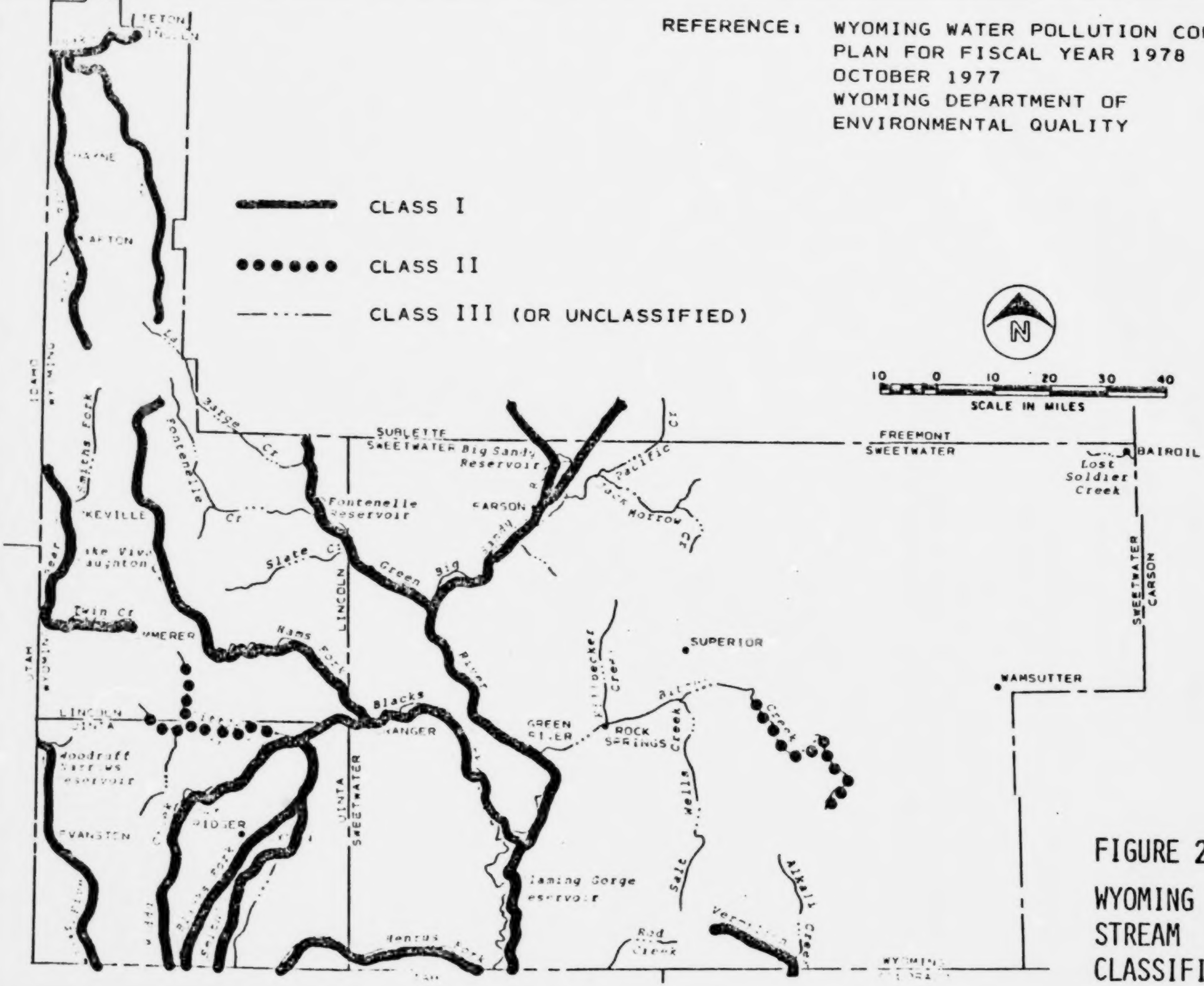
CLASS I
CLASS II
CLASS III (OR UNCLASSIFIED)
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
AFTON
IDAHO
WYOMING
Smiths Fork
KEVILLE
Bear
Twin Cr
MMERER
UTAH
WYOMING
LINCOLN
UINTA
Woodruff
Narrows
eservoir
EVANSTON
BRIDGER
Fontenelle
Cr
Barge
Cr
SUBLETTE
SWEETWATER
Big Sandy
Reservoir
Fontenelle
Reservoir
FARSON
Slate
Cr
LINCOLN
Green
Big
Sandy
Pacific
Cr
Jack Morrow
Cr
Hams Fork
Blacks
GRANGER
River
UINTA
SWEETWATER
Henrys Fork
GREEN
RIVER
ROCK
SPRINGS
Killpecker
Creek
SUPERIOR
Bitter
Creek
Salt
Wells
Creek
Flaming Gorge
Reservoir
Red
Creek
Vermillion
Alkali
Creek
WYOMING
COLORADO
FREEMONT
SWEETWATER
BAIROIL
Lost
Soldier
Creek
SWEETWATER
CARSON
WAMSUTTER

FIGURE 2-3
WYOMING
STREAM
CLASSIFICATIONS

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Table 2-5

WYOMING WATER QUALITY STANDARDS

	Class		
Parameter (1)	I	II	III
Fecal Coliform Geometric Mean	May 1 through September 30 200/100ml (2) primary contact 1000/100ml secondary contact	May 1 through September 30 200/100ml (2) primary contact 1000/100 ml secondary contact	May 1 through September 30 1000/100ml
Dissolved Oxygen	6.0 mg/l	5.0 mg/l	None
Floating Solids	Free From		
Oil and Grease	10 mg/l (maximum)		
pH	6.5 - 8.5 units		
Radioactive Material	BPT and 3 pCi/l Ra^{226}, 10 pCi/l Sr^{90} (maximum)		
Settleable Solids	Free From		
Taste, Odor, and Color	Free From	Free From	None
Temperature	Warm water fish 90°F (max.) Cold water fish 78°F (max.) 2°/4° maximum increase	Warm water fish 90°F (max.) Cold water fish 78°F (max.) 2°/4° maximum increase	None
Toxic Materials	Free From		
Turbidity	10 JTU (maximum increase)	10 JTU (maximum increase)	None
Total Gas Pressure	110% of atmosphere		

(1) Water quality standards from *Wyoming Water Quality Rules and Regulations*, *1974*.
(2) Applies to all still water bodies and certain streams.

to the standards on radioactive material and turbidity. Additional criteria have been developed for salinity, phosphorus and sediment.

A Water-Use Basis for Criteria

Instream water quality criteria in this study are use-based, as discussed at the beginning of this chapter. They have been designed to protect the existing and projected uses of water in the study area. In particular, the proposed criteria are designed to make surface waters suitable, wherever attainable, for primary and secondary contact recreation, wildlife, and fisheries in accordance with the national goal in PL 92-500. Whether the proposed criteria actually satisfy the requirements of PL 92-500 has not been tested yet. These criteria may be judged by the State or Federal government not to be in compliance with the Federal law. In this case, they should be revised.

Several assumptions were made about certain uses in the development of criteria. For example, some water treatment is assumed to occur before water is used by industry or municipalities. Most industries in the study area presently store water in a forebay or small pond to ensure a dependable water supply. During storage most of the suspended solids settle out. Storage is assumed to continue as an industrial practice in the study area, and therefore suspended solids criteria for industry have not been considered necessary.

Treatment is also assumed before water is used for public water supplies. The type of treatment is described on Table 2-1. This treatment is commonly done in the study area at the present time for surface water supplies. Because this treatment is assumed before use, no coliform limits have been set for drinking water supplies from surface waters. Conventional water treatment is capable of routinely eliminating fecal coliform in the raw drinking water supplies.

As noted on Table 2-1, fisheries criteria are based on the propagation and protection of rainbow trout. EPA's *Quality Criteria for Water* state many of the fishery criteria in terms of 96-hour LC_{50}, which is the concentration at which 50 percent of an indicator species population dies within 96 hours. These concentrations vary considerably for different species of fish. Fisheries criteria in this report were based on 96-hour LC_{50} for rainbow trout, which is one of the most sensitive species to contaminants in water. Rainbow trout is one of the two most important game fish within the study area.

Salinity Criteria

Salinity refers to the dissolved solids in water. The major dissolved species in the study area are sodium, potassium, calcium, magnesium, bicarbonate, chloride, and sulfate. The salinity criteria developed in this study include recommended levels for those dissolved species important to the desired water uses, as well as for total dissolved solids.

Salinity is recognized by the criteria as an important water quality constituent which can cause adverse physical and economic impacts on water users. Some of these impacts are addressed through the incorporation of EPA's *Quality Criteria for Water*. Table 2-6 shows the criteria related to salinity in the EPA publication. The chloride criterion protects the domestic water user from a salty taste in the water, and the sulfate criterion protects the domestic water user accustomed to lower sulfate concentrations from the laxative effects of temporarily high sulfate concentrations. Aquatic life is protected by the alkalinity criterion.

Table 2-6

EPA SALINITY CRITERIA

Constituent	Criterion
Alkalinity	20 mg/l or more as $CaCO_3$ for fresh water aquatic life except where natural concentrations are less
Chloride	250 mg/l or less for domestic water supplies
Hardness	No specific criterion recommended
Sulfate	250 mg/l or less for domestic water supplies

Further salinity criteria have been recommended by the Colorado River Basin Salinity Control Forum. The instream criteria adopted by the Forum call for the maintenance of 1972 total dissolved solids levels on the lower mainstem of the Colorado River. However, the criteria do not specify salinity levels in the Upper Basin for the benefit of the Upper Basin users.

Salinity criteria in addition to those shown on Table 2-6 have been developed to identify what salinity levels can be tolerated by irrigators, livestock and wildlife, industrial users and domestic users in the study area. These criteria are discussed below.

Salinity Criteria for Agricultural Irrigation. To the irrigators in the study area, total dissolved solids (TDS) and sodium adsorption ratios (SAR) are two parameters of primary concern. High TDS reduces the crop's ability to extract water from the soil, while high SAR ratios reduce the permeability of the soil. The inter-relationship between TDS and SAR is shown on Figure 2-4, where TDS is measured in terms of conductivity. Alfalfa, which is the most important crop in the study area, belongs to the "medium" tolerance category

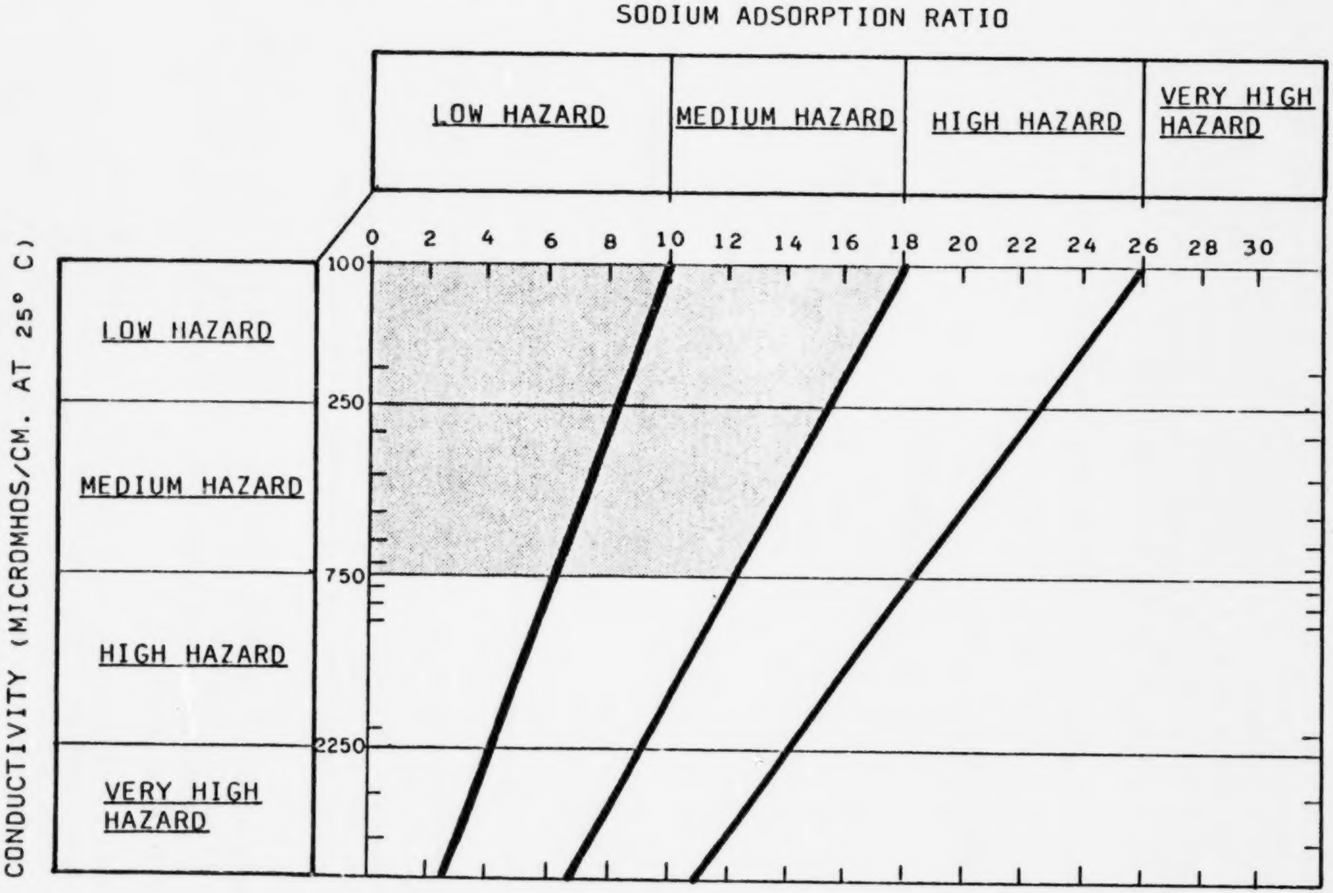

FIGURE 2-4

SALINITY CRITERION FOR AGRICULTURAL IRRIGATION

REFERENCE: USDA AGRICULTURAL HANDBOOK 60 (1954) for TDS and SAR, as defined by the U.S. Department of Agriculture. (1) Therefore, the water quality goal for irrigation in the study area is taken to be the shaded area on Figure 2-4.

It is important to note that Figure 2-4 should be strictly used for quality of the soil water solution. This water quality depends not only on the quality of the water applied to the land, but also on soil type, climate, and water management practices. Because of the lack of good soil solution water quality data in the study area, however, Figure 2-4 has been used to approximate the necessary quality in the water applied to the land.

Salinity Criteria for Wildlife and Livestock Watering. The Wyoming Department of Environmental Quality (DEQ) has imposed the following salinity effluent limitations on produced water: (2) chlorides not exceeding 2,000 mg/l, sulfates not exceeding 3,000 mg/l, and total dissolved solids not exceeding 5,000 mg/l. According to DEQ, these limits are based on the eventual use of produced water for livestock watering. These limits are suggested in this study as instream water quality criteria for wildlife and livestock watering.

Salinity Criteria for Industry. Higher salinity levels increase the water softening and demineralization costs for power plants and industries which require boiler-feed water, process water, or cooling tower water. The ideal water quality for industrial use is low mineral content in the water. Because this water quality is technologically and economically unfeasible to attain for the surface waters where industrial use is indicated, the industries in the study area will bear some softening or demineralization costs. The salinity criteria should give an indication of where these costs are excessive.

The salinity criteria for industry in this study indicate the level where estimated costs for salinity control exceed the benefits to the study area. A benefit-cost analysis has already been made on the entire Colorado River Basin for the Colorado River Basin Salinity Control Forum. The result of the basin-wide study was the present position by the Forum that salinity should not rise above 1972 levels in the Lower Colorado River Basin. A benefit-cost analysis within the study area provides information to Wyoming on whether instream or Stateline salinity standards would be beneficial to the State. This analysis is done in Chapter 8.

The costs for salinity control in the study area are expected to be high. Therefore, salinity criteria have been considered for those reaches where the potential benefits to industry from reduced salinity levels are possibly large enough to balance out the high costs of salinity control. As discussed later in Chapter 6, large industrial diversions exist or are projected to occur only in six reaches--Big Island (#16), Green River (#17), Lower Green River (#18), Green River Arm (#19), Blacks Fork Arm (#38), and Middle Hams Fork (#47). In this study only these six reaches have salinity criteria for industry. Specific values for the criteria in these reaches are presented in Chapter 8 after an analysis of benefits and costs.

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(1) U.S. Department of Agriculture, 1954, *Agricultural Handbook*, 60.

(2) Produced water is defined in the *Wyoming Water Quality Rules and Regulations*, Chapter VII, 1977, as underground water which is brought to the surface through the pumping of oil and/or gas wells.

Salinity Criteria for Public Water Supply. EPA criteria on sulfates and chlorides have been discussed earlier and have been included as criteria. These criteria are related to health and aesthetic impacts of salinity.

Salinity also affects domestic water users economically through increased water softening costs or, in the absence of water softeners, increased soap costs. As with the industrial salinity criteria, the economically based public water supply criteria have been considered only for those reaches where the potential benefits to domestic water users from reduced salinity levels are great. As discussed later in Chapter 4, large public water supply diversions exist in four reaches--Bear River above Evanston (#6), Green River (#17), Middle Hams Fork (#47), and Lower Hams Fork (#48). In this study only these four reaches have economically based criteria for public water supply. Specific values for the economically based public water supply criteria will be developed from a benefit-cost analysis. This analysis is done in Chapter 8.

Phosphorus Criterion

Eutrophication is over-fertilization of rivers, lakes and reservoirs. Some of the conditions commonly associated with eutrophication are:

- High concentrations of phosphorus, nitrogen, and other nutrients
- Increased numbers and severity of algae and macrophyte (rooted weed) blooms
- Lack of oxygen in deeper waters
- Reduced clarity and increased odors
- Reduction in the number of fish species

Eutrophication is more common in lakes and reservoirs, where the nutrients delivered by streams can collect.

Eutrophication is an existing or potential problem in all the reservoirs and lakes in the study area. EPA has conducted eutrophication surveys on seven lakes and reservoirs within or near the study area. Results from these surveys indicate that a reduction in phosphorus levels is likely to reduce algae and weed growth. This improvement is likely to be accompanied by other improvements, such as better aesthetics, larger game fish populations, and higher dissolved oxygen levels.

EPA has recommended that phosphorus levels be kept below 0.025 mg/l in lakes and reservoirs and below 0.050 mg/l in streams. However, EPA has not considered the water quality data sufficiently strong to recommend that these phosphorus values be adopted as water quality criteria. No phosphorus criteria are listed in EPA's *Quality Criteria for Water*.

Eutrophication criteria developed in this study have been based on the relationship between phosphorus and water clarity. Transparency is only one of the measures of eutrophication. It has been selected for this study because--

- There is sufficient data on it.
- Water clarity is a measure of water quality aesthetics to all types of recreational users.
- It correlates well in the study area with other measures of eutrophication, such as algal and macrophyte biomass, and anoxia.

Figure 2-5 depicts the relationship between Secchi desk transparency and total phosphorus in the surface waters of seven lakes and reservoirs in Southwestern Wyoming, Eastern Utah and Eastern Idaho. More than one location was sampled in many reservoirs. The upstream station is labeled "1", and other stations are numbered consecutively downstream. Three samples were taken at most locations, one in late spring, one in midsummer, and one in early fall. Therefore, three points are plotted for most locations. For example, the three points labeled "V3" depict the water quality at three different times of the year at the downstream station in Viva Naughton Reservoir.

Figure 2-5 indicates that a correlation exists between phosphorus concentrations and transparencies in all reservoirs except Viva Naughton. In general, higher phosphorus concentrations are associated with lower transparencies. A possible conclusion is that high phosphorus concentrations produce severe algae blooms, which in turn reduce the transparency of the water. Silt and suspended sediment may also affect transparency. However, the strong correlation between phosphorus and transparency in six of the seven water bodies at different times of the year suggests that algal growth is the more important factor affecting water transparency. Some other factor besides phosphorus may be limiting algal growth in Viva Naughton Reservoir, which does not follow the pattern shown for the other water bodies on Figure 2-5(1).

As shown on the figure, the relationship between transparency and total phosphorus in the surface waters is not linear. This nonlinear pattern may be caused by the conversion of algal populations at high phosphorus concentrations from green algae to blue-green algae, which tend to clump near the surface and severely restrict water clarity. There is little improvement

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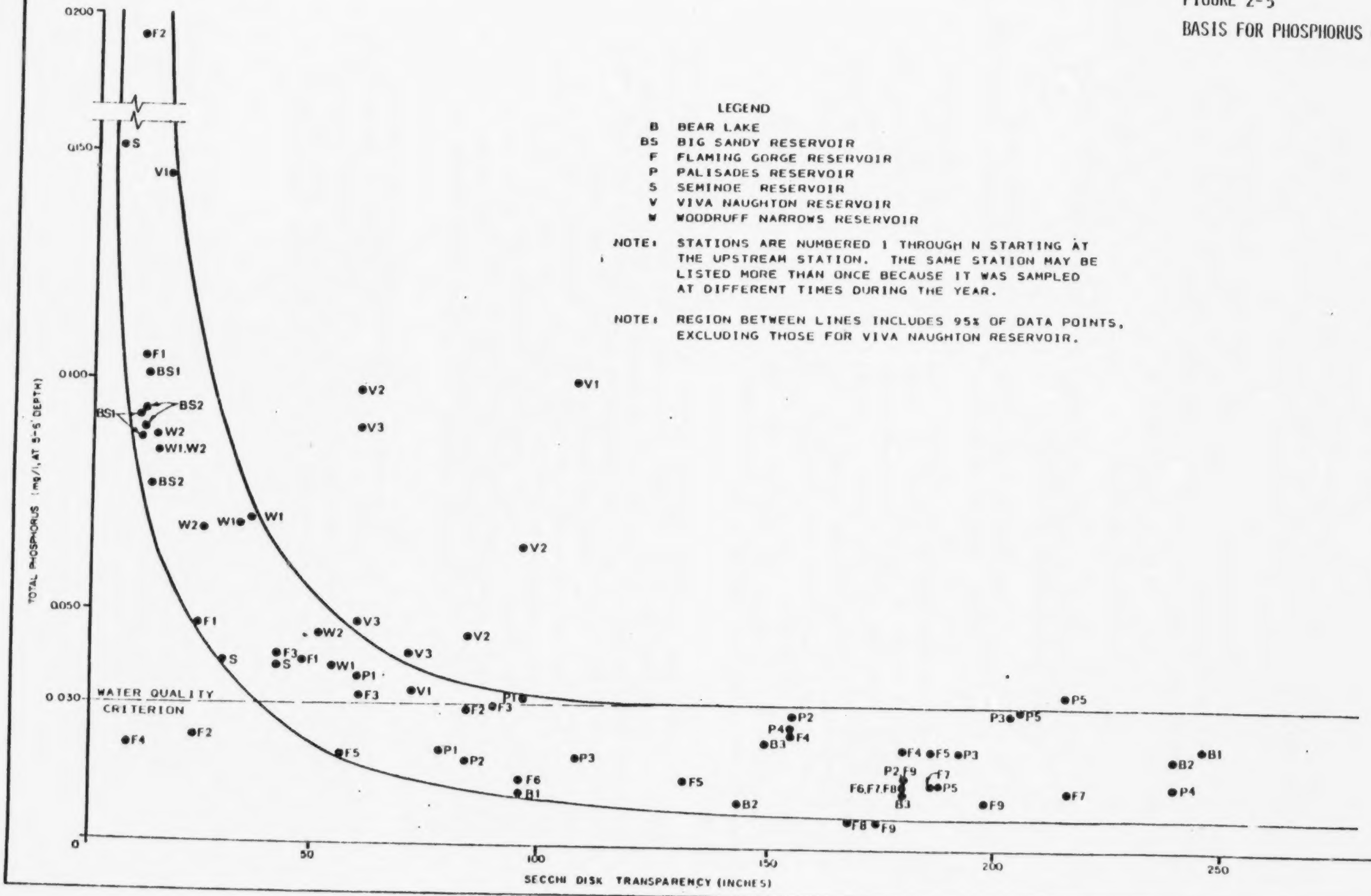
(1) Another possible explanation is that arsenic in the water is interfering in the analytical test for phosphorus; this interference would explain why phosphorus values appear higher than transparencies warrant.

FIGURE 2-5
BASIS FOR PHOSPHORUS CRITERION



NOTE: STATIONS ARE NUMBERED 1 THROUGH N STARTING AT THE UPSTREAM STATION. THE SAME STATION MAY BE LISTED MORE THAN ONCE BECAUSE IT WAS SAMPLED AT DIFFERENT TIMES DURING THE YEAR.

NOTE: REGION BETWEEN LINES INCLUDES 95% OF DATA POINTS, EXCLUDING THOSE FOR VIVA NAUGHTON RESERVOIR.

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in transparency until phosphorus concentrations in the surface waters drop below 0.080 mg/l, and there is no significant improvement in transparency for phosphorus reductions below 0.030 mg/l. A phosphorus level of 0.030 mg/l in the surface waters is a reasonable water quality goal, because no significant improvement in transparency is predicted through further phosphorus reductions. This phosphorus level is predicted to produce water quality in the area's reservoirs and lakes equivalent to the present conditions in Bear Lake or the lower reaches of Flaming Gorge Reservoir and Palisades Reservoir.

There are not sufficient transparency data on the area's streams to recommend a phosphorus criterion for streams on the basis of transparency. The existing phosphorus loads in the streams have not impaired the recreational use on them due to excessive algae or weed growths. Algal and weed growth is heavy on the Blacks Fork below Lyman, but little recreational activity occurs in this area. Algal growth is also moderately heavy in the Big Island and Green River reaches of the Green River. This growth has caused some clogging of industrial and municipal intakes in these reaches. In order to reach desirable phosphorus concentrations in the lakes and reservoirs, phosphorus loads carried by streams will have to be reduced from their existing levels. Thus, the phosphorus criterion for lakes and reservoirs may also protect the major streams from eutrophication.

Sediment Criterion

Turbidity and total suspended solids are frequently considered synonymous, since both are often related to sediments. High turbidity or high suspended solids in the Southwestern Wyoming area indicate that erosion has taken place. Furthermore, high levels of either generally indicate a potential impairment to fisheries, irrigation, and recreation.

There is no instream Wyoming standard for suspended solids. There is an effluent Wyoming turbidity standard measured in Jackson Turbidity Units (JTU). Point sources may not increase Turbidity by more than 10 JTU over the seasonal norm. The EPA criterion for sediment is in terms of a change in the compensation point from the seasonal norm.(1) However, the water quality data on sediments are generally given in mg/l of total suspended solids. Because the Wyoming standard and the EPA criterion for sediment are in different units than the units used to measure sediment concentrations in the study area, violations of the standard or criterion cannot be identified.

The *Interim Clean Water Report* for this study area presented possible criteria for sediment based on the protection of fisheries. Those criteria and their references are listed on Table 2-7. All of those criteria are measured in the traditional units of mg/l of total suspended solids.

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(1) The compensation point is the depth below the surface at which oxygen consumption from respiration and decomposition equals oxygen production by photosynthesis.

Table 2-7

POSSIBLE FISHERIES CRITERIA FOR SEDIMENT
(mg/l of total suspended solids)

Level of Protection	National Academy of Science, 1972 (1)	McKee and Wolf, 1963 (2)	EPA, Oct. 10, 1975 (3)	Davies & Goettl, July 1976 (4)
Ultimate	25	None	25	None
Good	80	Given	80	Given
Fair	400		400	

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(1) National Academy of Science and National Academy of Engineering, 1972, *Water quality criteria, 1972.*

(2) Jack Edward McKee and Harold W. Wolf, 1963, *Water quality criteria.*

(3) U.S. Environmental Protection Agency, Oct. 10, 1975, *Quality criteria for water*, draft.

(4) Patrick H. Davies and John P. Goettl, July 1976, *Aquatic life--Water quality recommendations for heavy metals and other inorganic toxicants in fresh water.*

However, none of those criteria has been adopted by Wyoming as a standard or accepted by EPA as a criterion.

In order to measure a fisheries use impairment, this study has used 80 mg/l of total suspended solids as the criterion for sediment. It is recognized that this criterion may not reflect existing or potential fisheries use impairment. However, until more information is gathered on harmful sediment levels to fish in the study area, it will be used to indicate water quality problems.

SURFACE WATER QUALITY CRITERIA

The previous section described the development of water quality criteria for this study. Most of them were taken from three references--the National Interim Primary Drinking Water Regulations, *Quality Criteria for Water*, and the existing Wyoming water quality standards. A phosphorus criterion, a sediment criterion, and some salinity criteria were derived from other sources of information. Their development was described in the previous section.

This section presents the water quality criteria to be used in this study to judge water quality. They have been separated into those for constituents whose concentrations have been monitored and those for constituents on which no water quality data have been collected.

Instream Criteria For Sampled Constituents

The instream water quality criteria for each surface water use are presented on Table 2-8 for 32 of the constituents on which some water quality data have been collected. The source of the criteria for each use is identified on Table 2-9. Four criteria have been developed specifically for this study. They are total phosphorus, SAR, TDS, and total suspended solids.

As noted on Table 2-8, criteria for primary contact recreation, secondary contact recreation, and agricultural irrigation apply only to the period from May 1 to September 30. These uses are not expected to occur during late fall and winter.

Several of the fisheries criteria listed on Table 2-8 have two levels based on whether the fishery is game or nongame and whether the water is hard or soft. Designations of game and nongame fisheries have been taken from *Stream Classifications in Wyoming*, dated October 1, 1976. The only designated nongame fisheries in the study area occur in Twin Creek, Upper Bitter Creek, the Blacks Fork reaches downstream of Smiths Fork, and Little Muddy Creek.

A reach has been classified "hard water" if the average total hardness concentration at a station in the reach exceeds 150 mg/l as $CaCO_3$. Those reaches classified as "hard water" are Lower Big Sandy River; all Blacks Fork reaches except Upper Blacks Fork; Lower Muddy Creek; and Twin Creek during the October 1 - February 28 period.

The metal criteria on Table 2-8 pertain to the dissolved species only. Toxicity data are not adequate to set criteria for the particulate forms.

Table 2-8

SURFACE WATER QUALITY CRITERIA BY USE FOR SAMPLED CONSTITUENTS(1)

Constituent	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Reservoir and Lake Aesthetics	Industrial Water Supply	Agricultural Irrigation(2)	Wildlife and Livestock Watering	Public Water Supply	Fishery
Alkalinity									>20
Ammonia, un-ionized (as N)									0.02
Arsenic						0.10		0.05	
Barium								1.0	
Beryllium						0.50			0.011 (soft) 1.1 (hard)
Boron						0.75			
Cadmium								0.010	0.0004 (soft) 0.0012 (hard)
Chloride							2,000	250	
Chromium								0.05	0.10
Coliform, Fecal (#/100ml)	1,000(2)	200(2)							
Color			Free from	Free from					(5)
Copper								1.0	0.006 (soft) 0.06 (hard)
Fluoride								2.2	
Iron									1.0
Lead								0.05	0.01 (soft) 5 (hard)
Mercury (µg/l)							0.05	2	0.05
Nickel									0.1 (soft) 1.0 (hard)
Nitrate + Nitrite (as N)								10	
Oxygen, Dissolved			Aerobic	Aerobic					6.0
pH (units)									6.5-8.5
Phenol								0.001	
Phosphorus, Total (as P)				0.03					
Polychlorinated Biphenyls									0.001
Radioactivity Gross Alpha Particle Activity (pCi/l)								15	
Selenium								0.01	0.025
Sodium Adsorption Ratio						(4)			
Solids, Total Dissolved					(3)	(4)	5,000	(3)	
Solids, Total Suspended									80
Sulfate							3,000	250	
Temperature (Max. change in degrees C)									1.1° (cold water) 2.2° (warm water)
Turbidity (Max. increase in JTU)									10 (game) 15 (nongame)
Zinc								5.0	0.009 (soft) 0.072 (hard)

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(1) All criteria are in mg/l except for pH, sodium adsorption ratio, and where specified.
(2) Criteria apply only to the May 1-September 30 period.
(3) Criterion will be determined in Chapter 8 after examination of costs and benefits.
(4) See Figure 2-4 in text.
(5) Should not reduce compensation point by more than 10 percent from seasonally adjusted norm.

Table 2-8

SURFACE WATER QUALITY CRITERIA BY USE FOR SAMPLED CONSTITUENTS(1)

Constituent	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Reservoir and Lake Aesthetics	Industrial Water Supply	Agricultural Irrigation(2)	Wildlife and Livestock Watering	Public Water Supply	Fishery
Alkalinity									>20
Ammonia, un-ionized (as N)									0.02
Arsenic						0.10		0.05	
Barium								1.0	
Beryllium						0.50			0.011 (soft) 1.1 (hard)
Boron						0.75			
Cadmium								0.010	0.0004 (soft) 0.0012 (hard)
Chloride							2,000	250	
Chromium								0.05	0.10
Coliform, Fecal (#/100ml)	1,000(2)	200(2)							
Color			Free from	Free from					(5)
Copper								1.0	0.006 (soft) 0.06 (hard)
Fluoride								2.2	
Iron									1.0
Lead								0.05	0.01 (soft) 5 (hard)
Mercury (µg/l)							0.05	2	0.05
Nickel									0.1 (soft) 1.0 (hard)
Nitrate + Nitrite (as N)								10	
Oxygen, Dissolved			Aerobic	Aerobic					6.0
pH (units)									6.5-8.5
Phenol								0.001	
Phosphorus, Total (as P)				0.03					
Polychlorinated Biphenyls									0.001
Radioactivity Gross Alpha Particle Activity (pCi/l)								15	
Selenium								0.01	0.025
Sodium Adsorption Ratio						(4)			
Solids, Total Dissolved					(3)	(4)	5,000	(3)	
Solids, Total Suspended									80
Sulfate							3,000	250	
Temperature (Max. change in degrees C)									1.1° (cold water) 2.2° (warm water)
Turbidity (Max. increase in JTU)									10 (game) 15 (nongame)
Zinc								5.0	0.009 (soft) 0.072 (hard)

---

(1) All criteria are in mg/l except for pH, sodium adsorption ratio, and where specified.
(2) Criteria apply only to the May 1-September 30 period.
(3) Criterion will be determined in Chapter 8 after examination of costs and benefits.
(4) See Figure 2-4 in text.
(5) Should not reduce compensation point by more than 10 percent from seasonally adjusted norm.

Table 2-9

SOURCE OF WATER QUALITY CRITERIA

Surface Water Use	Criteria Source
Secondary Contact Recreation	Wyoming Water Quality Standards
Primary Contact Recreation	Wyoming Water Quality Standards
Stream Aesthetics	*Quality Criteria for Water*
Reservoir and Lake Aesthetics	*Quality Criteria for Water* and 208 study
Industrial Water Supply	208 study
Agricultural Irrigation	*Quality Criteria for Water* and 208 study
Wildlife and Livestock Watering	*Quality Criteria for Water* and Wyoming standards for produced water
Public Water Supply	*National Interim Primary Drinking Water Regulations*, *Quality Criteria for Water* and 208 study
Fishery	*Quality Criteria for Water*, Wyoming Water Quality Standards, and 208 study

Water quality criteria for the constituents on Table 2-8 have been generated on a reach-by-reach basis on Table 2-10. When there are two or more criteria for a particular constituent in a reach, the stiffest criterion has been selected. For example, two arsenic criteria are applicable to Reach 6 (Bear River above Evanston), 0.10 mg/l for agricultural irrigation and 0.05 mg/l for public water supply. The arsenic criterion which appears on Table 2-10 is 0.05 mg/l, which is the stiffer of the two applicable arsenic criteria. As shown on Table 2-10, 22 sets of water criteria are needed to cover the various use combinations in the 52 reaches within the study area. The most common combination of uses is secondary contact recreation, stream aesthetics, agricultural irrigation, wildlife and livestock watering and fishery. This combination and associated criteria cover 19 of the 52 reaches.

Instream Criteria For Unsampled Constituents

Water quality criteria shown on Table 2-8 and Table 2-10 are for 32 constituents on which some water quality data have been collected in the study area. An additional 27 water quality criteria have no water quality data associated with them. Criteria for these 27 constituents are presented on a reach-by-reach basis on Table 2-11. The pesticide and metal criteria pertain to the soluble species.

GROUND WATER QUALITY CRITERIA

Four existing or projected uses have been identified for ground water in the study area. These uses are for industrial water supply, agricultural irrigation, wildlife and livestock watering, and domestic and public water supply. Water quality criteria for each of these uses are shown on Table 2-12.

The ground water quality criteria are the same as those used for evaluating surface water quality with a single exception. The fecal coliform criterion contained in the *National Interim Primary Drinking Water Regulations* (four colonies per 100ml) has been included in the ground water drinking supplies in the area are domestic rather than public water supplies and are not undergoing conventional disinfection treatment before use.

Table 2-10

SURFACE WATER QUALITY CRITERIA BY REACH FOR SAMPLED CONSTITUENTS (1)

Constituents	Reach 1	Reach 2,50	Reach 3,4,7,9, 10,12,21, 23,25,27, 34,37,40,42 45,49,51	Reach 5,24,46	Reach 6,39,48	Reach 8	Reach 11	Reach 13	Reach 14	Reach 15	Reach 16,18
Alkalinity (as $CaCO_3$)	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20	>20
Ammonia, Un-ionized (as N)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Arsenic (2)			0.10		0.05	0.10		0.10	0.05	0.10	0.10
Barium					1.0				1.0	1.0	
Beryllium (2)	0.011	0.011	0.011	0.011	0.011	0.011	0.011 (8)	0.011	0.011	0.011	0.011
Boron (2)			0.75		0.75	0.75		0.75	0.75	0.75	0.75
Cadmium	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0008 (8)	0.0004	0.0004	0.0004	0.0004
Chloride	2,000	2,000	2,000	2,000	250	2,000	2,000	2,000	250	250	2,000
Chromium	0.10	0.10	0.10	0.10	0.05	0.10	0.10	0.10	0.05	0.05	0.10
Coliform, Fecal (#/100ml) (3)	200	1,000	1,000	200	1,000	200	1,000	200	200	200	200
Color	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)
Copper	0.006	0.006	0.006	0.006	0.006	0.006	0.006 (8)	0.006	0.006	0.006	0.006
Fluoride					2.2				2.2	2.2	
Iron	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lead	0.01	0.01	0.01	0.01	0.01	0.01	0.01 (8)	0.01	0.01	0.01	0.01
Mercury (µg/l)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nickel	0.1	0.1	0.1	0.1	0.1	0.1	0.1 (8)	0.1	0.1	0.1	0.1
Nitrate + Nitrite (as N)					10				10	10	
Oxygen, Dissolved	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Phenol					0.001				0.001	0.001	
Phosphorus, Total (as P)				0.03		0.03			0.03	0.03	
Polychlorinated Biphenyls (µg/l)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Radioactivity--Cross Alpha Particle Density (pCi/l)					15				15	15	
Selenium	0.025	0.025	0.025	0.025	0.01	0.025	0.025	0.025	0.01	0.01	0.025
Sodium Adsorption Ratio (2)			(6)		(6)	(6)		(6)	(6)	(6)	(6)
Solids, Total Dissolved (2)	5,000	5,000	(6)	5,000	(5) (6)	(6)	5,000 (4)	(6)	(5) (6)	(5) (6)	(4) (6)
Solids, Total Suspended	80	80	80	80	80	80	80	80	80	80	80
Sulfate	3,000	3,000	3,000	3,000	250	3,000	3,000	3,000	250	250	3,000
Temperature	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Turbidity	10	10	10	10	10	10	15	10	10	10	10
Zinc	0.009	0.009	0.009	0.009	0.009	0.009	0.009 (8)	0.009	0.009	0.009	0.009

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(1) Reach designations are given on Table 2-2. All criteria are in mg/l except for pH, sodium adsorption ratio, and where specified.

(2) Agricultural irrigation criteria (arsenic when equal to 0.10 mg/l, beryllium when equal to 0.50 mg/l, boron, sodium adsorption ratio, and total dissolved solids) apply only to the May 1-September 30 period.

(3) Criterion applies only to the May 1-September 30 period.

(4) Criterion will be determined in Chapter 8 for industry after examination of costs and benefits.

(5) Criterion will be developed in Chapter 8 for public water supply after examination of costs and benefits.

(6) See Figure 2-4 in text.

(7) Should not reduce compensation point by more than 10 percent from seasonally established norm.

(8) Criterion applies to March 1-September 30 period. At other times, criteria are 1.1 mg/l for berryllium, 0.0012 mg/l for cadmium, 0.06 mg/l for copper, 5.0 mg/l for lead, and 1.0 mg/l for nickel, and 0.072 mg/l for zinc because of harder water.

Reach 17	Reach 19	Reach 20	Reach 26,43	Reach 28,30-33, 52	Reach 29	Reach 35	Reach 36	Reach 38	Reach 44	Reach 47
>20	>20	>20	>20		>20	>20	>20	>20	>20	>20
0.02	0.02	0.02	0.02		0.02	0.02	0.02	0.02	0.02	0.02
0.05	0.05	0.05			0.10	0.05	0.10	0.10		0.05
1.0	1.0	1.0				1.0				1.0
0.011	0.011	0.011	1.1		0.011	1.1	1.1	0.50	0.011	0.011
0.75					0.75	0.75	0.75	0.75		0.75
0.0004	0.0004	0.0004	0.0012		0.0004	0.0012	0.0012	0.0012	0.0004	0.0004
250	250	250	2,000	2,000	2,000	250	2,000	2,000	2,000	250
0.05	0.05	0.05	0.10		0.10	0.05	0.10	0.10	0.10	0.05
200	200	200	1,000	1,000	1,000	1,000	1,000	200	1,000	1,000
(7)	(7)	(7)	(7)		(7)	(7)	(7)	(7)	(7)	(7)
0.006	0.006	0.006	0.06		0.006	0.06	0.06	0.06	0.006	0.006
2.2	2.2	2.2				2.2				2.2
1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.00
0.01	0.01	0.01	5.		0.01	5.	5.	5.	0.01	0.01
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
0.1	0.1	0.1	1.0		0.1	1.0	1.0	0.1	0.1	0.1
10	10	10				10				10
6.0	6.0	6.0	6.0	Aerobic	6.0	6.0	6.0	6.0	6.0	6.0
6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5		6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
0.001	0.001	0.001				0.001				0.001
	0.03	0.03						0.03		
0.001	0.001	0.001	0.001		0.001	0.001	0.001	0.001	0.001	0.001
15	15	15				15				15
0.01	0.01	0.01	0.025		0.025	0.01	0.025	0.025	0.025	0.01
(6)					(6)	(6)	(6)	(6)		(6)
(4) (5) (6)	5,000 (4) (5)	5,000 (5)	5,000	5,000	(6)	(5) (6)	(6)	(4) (6)	5,000	(4) (5) (6)
80	80	80	80		80	80	80	80	80	80
250	250	250	3,000	3,000	3,000	250	3,000	3,000	3,000	250
1.1	1.1	1.1	1.1		1.1	1.1	2.2	1.1	1.1	1.1
10	10	10	10		15	10	15	10	15	10
0.009	0.009	0.009	0.072		0.009	0.072	0.072	0.072	0.009	0.009

Table 2-11

SURFACE WATER QUALITY CRITERIA FOR CONSTITUENTS WITH NO WATER QUALITY DATA(1)

Constituents	Reach(2)	Reach(3)	Reach(4)
Aesthetics	(5)	(5)	(5)
Chlorine, Free Residual	0.002	0.002(6)	
Cyanide	0.005	0.005	0.005
Gases, Total Dissolved (% saturation)	<110	<110	
Oil and Grease	10	10	
Pesticides (µg/l)			
2, 4-D	100		
2, 4, 5-TP, Silvex	10		
Aldrin-Dieldrin	0.003	0.003	
Chlordane	0.01	0.01	
DDT	0.001	0.001	
Demeton	0.1	0.1	
Endosulfan	0.003	0.003	
Endrin	0.004	0.004	
Guthion	0.01	0.01	
Heptachlor	0.001	0.001	
Lindane	0.01	0.01	
Malathion	0.1	0.1	
Methoxychlor	0.03	0.03	
Mirex	0.001	0.001	
Parathion	0.04	0.04	
Toxaphene	0.005	0.005	
Phthalate Esters	0.003	0.003	
Radioactivity (pCi/l)			
Radium-226 + Radium-228	5	5	
Strontium-90	8	8	
Silver	0.05		
Solids, Settleable and Floating	Free from	Free from	
Sulfide, Undissociated Hydrogen	0.002	0.002	

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(1) All units in mg/l except as noted. Data used in this report came from WRDS, STORET, and the SWWQPA monitoring program.

(2) Reaches 6, 14, 15, 17, 19, 20, 35, 39, 47, 48. Reach designations are listed on Table 2-2.

(3) Reaches 1-5, 7-13, 16, 18, 21-27, 29, 34, 36-38, 40-46, 49-51. Reach designations are listed on Table 2-2.

(4) Reaches 28, 30-33, 52. Reach destinations are listed on Table 2-2.

(5) Free from substances which settle to form objectionable deposits; which float as debris, scum, oil, or other matter to form nuisances; which produce objectionable color, odor, taste, or turbidity; which produce undesirable or nuisance aquatic life; and which injure, are toxic, or produce adverse physiological responses in humans, animals, or plants.

(6) Criterion is 0.01 mg/l for nongame fisheries (Reaches 11, 29, 36, 44).

Table 2-12

GROUND WATER QUALITY CRITERIA BY USE(1)

	Criterion			
Constituent	Industrial Water Supply	Agricultural Irrigation (2)	Wildlife and Livestock Watering	Public Water Supply
Arsenic		0.10		0.05
Barium				1.0
Beryllium		0.50		
Boron		0.75		
Cadmium				0.010
Chloride			2,000	250
Chromium				0.05
Coliform, Fecal (#/100ml)				4
Copper				1.0
Fluoride				2.2
Lead				0.05
Mercury (mg/l)			0.05	2
Nitrate + Nitrite (as N)				10
Organic Chemicals				
2, 4-D				0.1
2, 4, 5-TP Silvex				0.01
Endrin				0.0002
Lindane				0.004
Methoxychlor				0.1
Toxaphene				0.005
Phenol				0.001
Radioactivity (pCi/l)				
Gross Alpha Particle Activity				15
Radium 226+ Radium 228				5
Selenium				0.01
Silver				0.05
Sodium Adsorption Ratio		(5)		
Solids, Total Dissolved	(3)	(5)	5,000	(4)
Sulfate			3,000	250
Zinc				5.0

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(1) All criteria in mg/l except for Sodium Adsorption Ratio or unless otherwise noted.

(2) Agricultural irrigation criteria apply only to the March 1-September 30 period.

(3) Criterion will be developed later in report for industry after examination of costs and benefits.

(4) Criterion will be developed later in report for public water supply after examination of costs and benefits.

(5) See Figure 2-4 in text.

Chapter 3
EXISTING INSTREAM WATER QUALITY

Most waters in the study area are sustaining fish and wildlife, do not pose any health hazards, and are suitable for recreational purposes. However, several reaches within the study area do have water quality problems.

Water quality problems are defined in this study in terms of the use of the water, just as quality criteria have been given in Chapter 2 in terms of use. A water quality problem is considered to exist when the quality prohibits or impairs the identified use of that water. In other words, an existing or potential use impairment is assumed to occur when instream concentrations exceed the water quality criteria developed in Chapter 2. This chapter identifies those reaches where existing water quality presents an impairment of existing or projected uses of the reaches as established in Chapter 2. Use impairment by projected future water quality is discussed in Chapter 6.

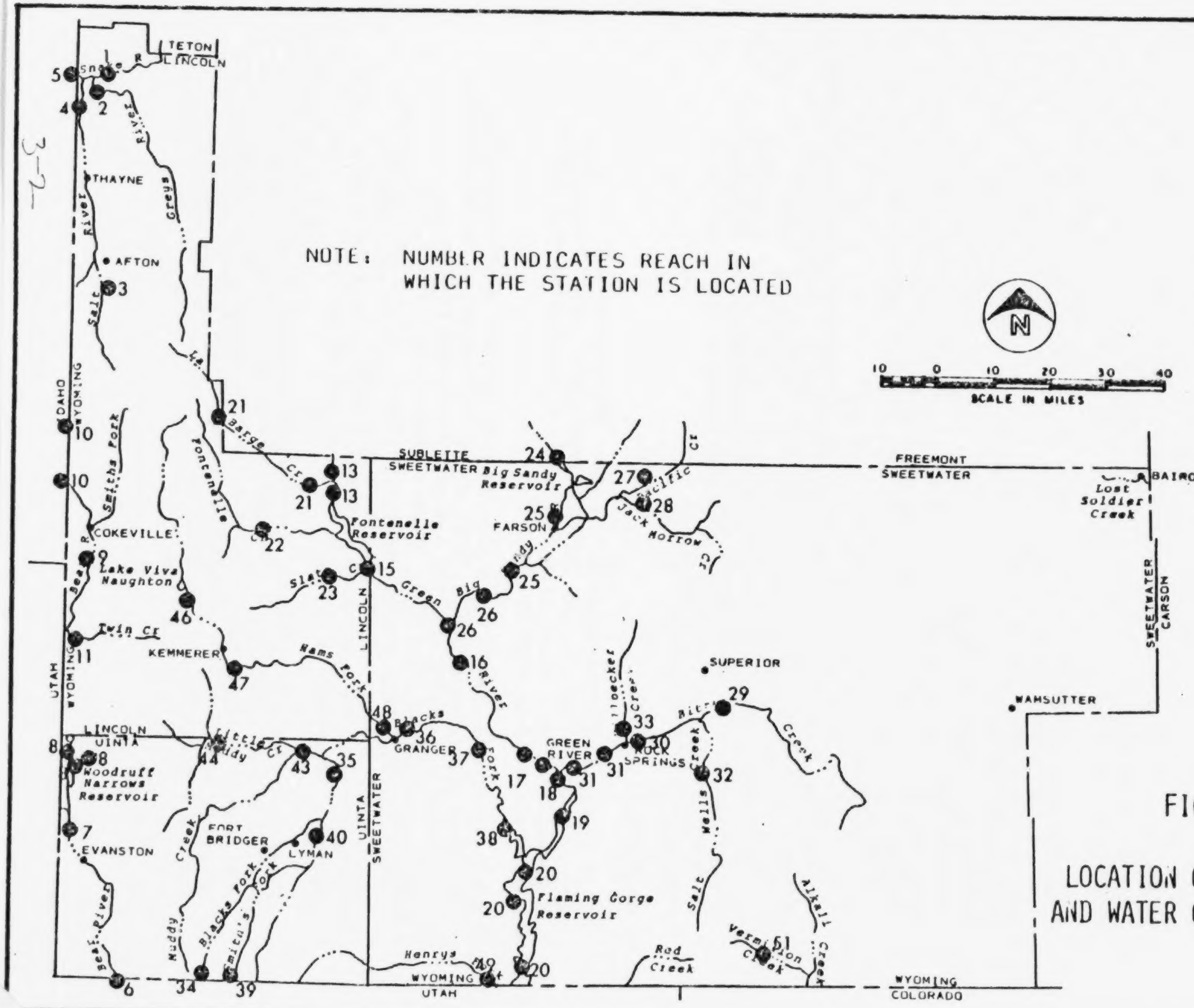
The Wyoming Department of Environmental Quality (DEQ) has documented several instances of instream concentrations in the study area exceeding existing State and Federal water quality standards. These violations of water quality standards are mentioned in this chapter. In all cases, the reaches with violations of the standards also show use impairment. Use impairment as defined in this report occurs when concentrations in a particular reach have exceeded the criteria for the use.

WATER QUALITY DATA

Water quality data are abundant for the area. The abundance of data is largely a result of documented salinity problems downstream in the Lower Colorado River Basin and an early recognition of the potential water quality impacts of energy development in the area.

Water quality data used in this study come from STORET, the Wyoming Water Resources Data System (WRDS), and a monitoring program set up by SWWQPA. Locations of the water quality and flow gauging stations used in this report are shown on Figure 3-1. These stations are identified by the STORET or WRDS name and number in Appendix A. Most of the stations are located at the downstream end of a reach. Water quality within a reach is a composite of all the water quality information from all the stations in that reach. Water quality data cover the 1970-1976 period.

Three categories of water quality information exist within the study area. The first category includes 18 constituents for which water quality data exist in the study area, but for which no instream water quality criteria have been developed. These constituents are calcium and total hardness, total and dissolved Kjeldahl nitrogen, nitrite, dissolved reactive phosphorus,


NOTE: NUMBER INDICATES REACH IN WHICH THE STATION IS LOCATED
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
River
Greys
THAYNE
AFTON
Salt
IDAHO
WYOMING
Smiths Fork
COKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
UTAH
WYOMING
KEMMERER
La Barge Cr
Fontenelle
Fontenelle Reservoir
Slate Cr
Hams Fork
LINCOLN
SWEETWATER
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
Bear River
Little Muddy Cr
Muddy Creek
FORT BRIDGER
LYMAN
Blacks Fork
Smith's Fork
UINTA
SWEETWATER
GRANGER
Blacks Fork
Green River
Big Sandy
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Pacific Cr
Jack Morrow Cr
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
SUPERIOR
Killpecker Creek
Bitter Creek
GREEN RIVER
ROCK SPRINGS
Salt Wells Creek
Flaming Gorge Reservoir
Henrys Fork
Red Creek
Vermillion Creek
Alkali Creek
WYOMING
UTAH
WYOMING
COLORADO
1
2
3
4
5
6
7
8
8
9
10
10
11
13
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49
51

FIGURE 3-1

LOCATION OF FLOW GAUGING AND WATER QUALITY STATIONS chemical and biochemical oxygen demand, potassium, sodium, aluminum, magnesium, manganese, molybdenum, vanadium, conductivity, carbon dioxide, and algal biomass.

A second category includes 27 constituents with water quality criteria but without water quality data available from any of the data sources used in this report. These constituents are listed on Table 2-10. There are two explanations why these constituents may not have been monitored in the past. Many are organic chemicals that are not routinely analyzed and are expensive to analyze. Also, water quality monitoring agencies have apparently assumed that these constituents are not likely to reach critical levels in the study area.

The final group includes 32 water quality constituents for which criteria have been developed and for which data are available. These constituents are listed on Table 2-9. Where water quality data and criteria on a constituent are available, use impairments can be identified by measuring existing water quality against the desirable water quality for each use. If all the constituents with criteria in a reach have associated water quality data, confident identification can be made of all use impairments in a reach. However, in most reaches, many of the constituents with criteria do not have water quality data associated with them. Figure 3-2 indicates those reaches with the most complete sampling of all constituents with criteria. At least 75 percent of the constituents with criteria have been monitored one or more times in the 22 reaches called out on the figure.

The extent of the water quality monitoring program to date is shown on Table 3-1 for the 32 constituents for which water quality criteria have been developed and on which water quality data are available. Several conclusions can be made about the water quality monitoring program to date from information contained on the table:

- Extensive monitoring of water quality has taken place in the study area.
- The monitoring program has emphasized salinity-related and eutrophication-related constituents, dissolved oxygen, temperature and pH.
- The monitoring program has been relatively weak in metals, in organics such as phenols and polychlorinated biphenyls, and in aesthetic-related constituents such as color.
- Widespread monitoring of fluoride, nitrates, and phosphorus has occurred in reaches where the criteria for these constituents are not applicable because the uses associated with the criteria are not designated for those reaches.

DOCUMENTED WATER QUALITY PROBLEMS

DEQ publishes a 305(B) report each year which documents general surface water quality in Wyoming, violations of State Water Quality Standards, and

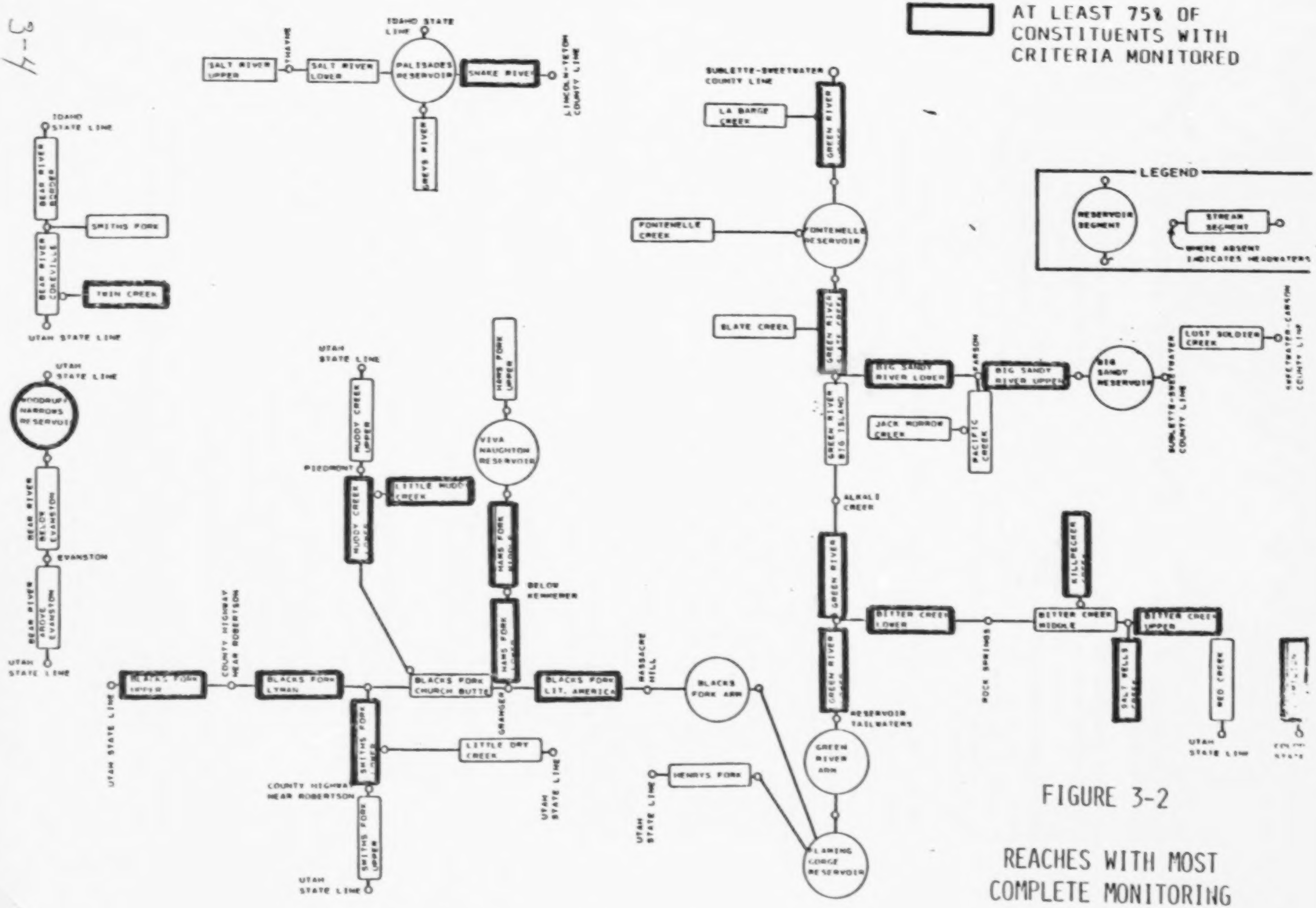
AT LEAST 75% OF CONSTITUENTS WITH CRITERIA MONITORED
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
IDAHO STATE LINE
BEAR RIVER BORDER
SMITHS FORK
BEAR RIVER COKEVILLE
TWIN CREEK
UTAH STATE LINE
UTAH STATE LINE
WOODRUFF NARROWS RESERVOIR
BEAR RIVER BELOW EVANSTON
EVANSTON
BEAR RIVER ABOVE EVANSTON
UTAH STATE LINE
SALT RIVER UPPER
THAYNE
SALT RIVER LOWER
IDAHO STATE LINE
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
JACK MORROW CREEK
PACIFIC CREEK
GREEN RIVER BIG ISLAND
ALKALI CREEK
GREEN RIVER
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
GREEN RIVER
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
UTAH STATE LINE
UTAH STATE LINE
MUDDY CREEK UPPER
PIEDMONT
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
HAMS FORK UPPER
VIVA NAUGHTON RESERVOIR
HAMS FORK MIDDLE
BELOW KEMMERER
HAMS FORK LOWER
UTAH STATE LINE
BLACKS FORK UPPER
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK LYMAN
BLACKS FORK CHURCH BUTTE
GRANGER
BLACKS FORK LIT. AMERICA
MASSACRE HILL
BLACKS FORK ARM
SMITHS FORK LOWER
LITTLE DRY CREEK
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE

FIGURE 3-2

REACHES WITH MOST COMPLETE MONITORING

Table 3-1

EXTENT OF WATER QUALITY MONITORING IN STUDY AREA

Constituent	Water Quality Criterion and Data	Water Quality Criterion, No Data	Water Quality Data, Criterion Not Applicable	Water Quality Criterion Not Applicable, No Data
		(Number of Reaches)		
Adequate Monitoring				
Alkalinity	36	10	5	1
Boron	24	10	11	7
Chloride	35	17	0	0
Fluoride	9	3	26	14
Oxygen, Dissolved	39	13	0	0
pH	34	12	4	2
Phosphorus, Total	7	1	27	17
Sodium Adsorption Ratio (SAR)	26	8	10	8
Solids, Total Dissolved	33	19	0	0
Sulfate	37	15	0	0
Temperature	38	8	6	0
Poor Monitoring				
Ammonia, Un-ionized	26	20	3	3
Arsenic	16	20	5	11
Cadmium	21	25	2	4
Chromium	18	28	2	4
Coliform, Fecal	27	25	0	0
Copper	18	28	2	4
Iron	27	19	5	1
Lead	24	22	5	1
Mercury	21	31	0	0
Nickel	17	29	1	5
Nitrate + Nitrite	7	5	16	24
Selenium	20	26	2	4
Solids, Total Suspended	27	19	5	1
Turbidity	28	18	5	1
Zinc	23	23	2	4
Inadequate				
Barium	2	10	7	33
Beryllium	12	34	3	3
Color	1	45	0	6
Phenol	0	12	1	39
Polychlorinated Biphenyls	6	40	0	6
Radioactivity--Gross Alpha Particle Activity	1	11	1	39

violations of NPDES discharge permits. Violations of State Water Quality Standards in 1976 in the study area are shown on Figure 3-3. The temperature violations were considered marginal and not harmful to fisheries. Widespread violations of the pH standard were also found in the study area; however, all these violations were marginal and attributed to natural causes.

The Green River in the Lower Green River reach was designated by DEQ as a "problem segment" because of high fecal coliform and nutrient concentrations. Killpecker Creek was identified as a possible "problem segment."

MEASUREMENT OF WATER QUALITY

Two interpretations of use impairment have been made in this study. Under the first interpretation, a water use is considered impaired if the concentration in any sample exceeds the water quality criterion. Under the second interpretation, a water use is considered impaired if the concentrations of a particular constituent exceed the water quality criteria for that use a certain percentage of the time. Which of the two interpretations of water quality is the more suitable depends on the constituent being considered. The selected approach to each constituent whose water quality criteria have been exceeded is presented on Table 3-2.

Maximum-Concentration Approach

The maximum-concentration approach has been selected for all constituents associated with acute or short-term effects. These effects include--

- The toxicity to fish of temporarily high ammonia or low dissolved oxygen concentrations.
- The greater possibility of bacterial and viral infections with consumption of water containing fecal coliforms.
- Eutrophication associated with temporarily high phosphorus concentrations.
- The laxative consequences of water temporarily high in sulfates.
- Dehydration in livestock and wildlife because of their avoidance of water temporarily high in chlorides.
- Blood disorders in infants drinking water temporarily high in nitrates and nitrites.

Table 3-3 identifies those reaches in which concentrations in any sample have exceeded the criteria. Under this first interpretation of water quality, every use except stream aesthetics has at least one reach where impairment of that use occurs. Fishery has the greatest number of impaired reaches; 29 of the 34 reaches on which data are available, and 29 of the 46 reaches which designate a fishery as an existing or potential use, show impairment of this use.

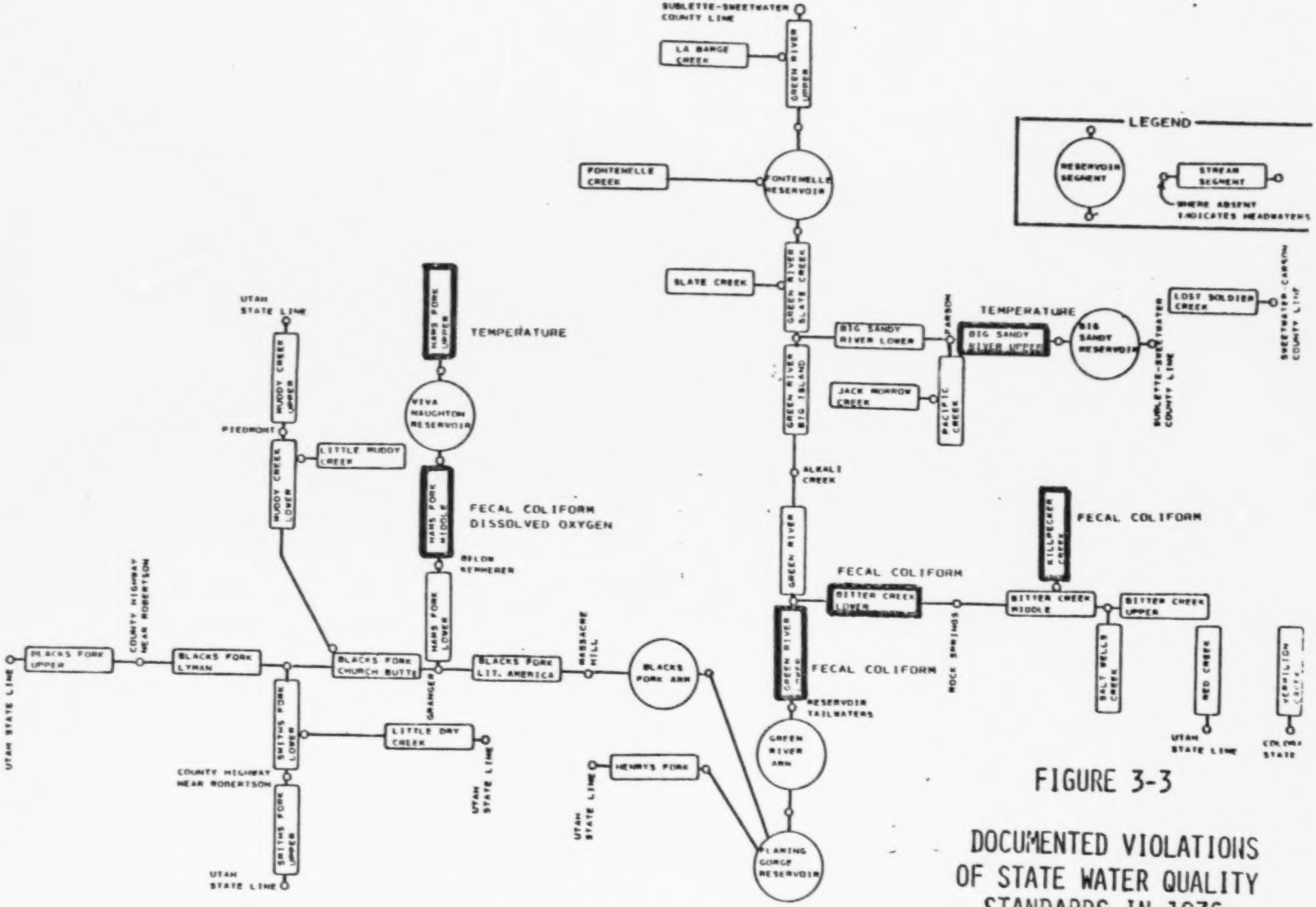
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
SUBLETTE-SWEETWATER COUNTY LINE
GREEN RIVER UPPER
LA BARGE CREEK
FONTENELLE RESERVOIR
FONTENELLE CREEK
GREEN RIVER SLATE CREEK
SLATE CREEK
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
TEMPERATURE
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
JACK MORROW CREEK
PACIFIC CREEK
GREEN RIVER BIG ISLAND
ALKALI CREEK
GREEN RIVER
BITTER CREEK LOWER
FECAL COLIFORM
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
FECAL COLIFORM
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
VERMILION CREEK
COLORADO STATE
GREEN RIVER LOWER
FECAL COLIFORM
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
UTAH STATE LINE
BLACKS FORK ARM
MASSACRE HILL
BLACKS FORK LIT. AMERICA
GRANGER
HAMS FORK LOWER
BELOW KEMMERER
HAMS FORK MIDDLE
FECAL COLIFORM
DISSOLVED OXYGEN
VIVA NAUGHTON RESERVOIR
HAMS FORK UPPER
TEMPERATURE
BLACKS FORK CHURCH BUTTE
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
PIEDMONT
MUDDY CREEK UPPER
UTAH STATE LINE
LITTLE DRY CREEK
UTAH STATE LINE
SMITHS FORK LOWER
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
BLACKS FORK LYMAN
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK UPPER
UTAH STATE LINE

FIGURE 3-3

DOCUMENTED VIOLATIONS OF STATE WATER QUALITY STANDARDS IN 1976

Table 3-2

MEASUREMENT OF WATER QUALITY

	Selected Approach to Water Quality	
Constituent	Maximum Concentration In Any Sample Greater Than Water Quality Criterion	Concentration Greater Than Water Quality Criterion One-Half of the Time
Ammonia, Un-ionized	X	
Beryllium		X
Boron		X
Cadmium		X
Chloride	X	
Coliform, Fecal	X	
Copper		X
Iron		X
Lead		X
Mercury		X
Nitrate-Nitrogen	X	
Oxygen, Dissolved	X	
pH		X
Phosphorus, Total	X	
SAR-TDS		X
Solids, Total Dissolved		X
Solids, Total Suspended		X
Sulfate	X	
Zinc		X

Table 3-3

REACHES IN WHICH CRITERIA ARE EXCEEDED IN ANY SAMPLE

Use	Exceeded Criterion (1)	Reach Number (2)
Secondary Contact Recreation	Fecal Coliform	18, 29, 31, 32, 33, 40, 47
Primary Contact Recreation	Fecal Coliform (Local Goal)	13, 15, 16, 17, 18
	Fecal Coliform (National Goal)	10, 13, 15, 16, 17, 18, 25, 35, 36, 37, 47
Stream Aesthetics	None	
Reservoir and Lake Aesthetics	Total Phorphorus	5, 8, 19, 20, 24, 38, 46
Industrial Water Supply	Total Dissolved Solids	Criterion not yet developed
Agricultural Irrigation	Boron	40, 47
	SAR-TDS	10, 16, 17, 18, 25, 27, 29, 35, 37, 40, 48, 51
Wildlife and Livestock Watering	Chloride	33
	Mercury	1, 13, 15, 17, 25, 44, 51
	Sulfate	29, 33
	Total Dissolved Solids	33
Public Water Supply	Nitrate	4
	Radioactivity--Gross Alpha Particle Activity	40
	Sulfate	17, 20, 35, 48
	Total Dissolved Solids	Criterion not yet developed
Fishery	Ammonia, Un-ionized (worst conditions)	1, 13, 17, 18, 27, 29, 43, 44, 47, 48, 51
	Ammonia, Un-ionized (average conditions)	None
	Beryllium	27, 34
	Cadmium	1, 8, 11, 13, 15, 17, 18, 25, 29, 39, 40, 44, 47, 48, 51
	Copper	8, 11, 13, 17, 25, 48
	Iron	35
	Lead	1, 13, 17, 20
	Mercury	1, 13, 15, 17, 25, 44, 51
	Oxygen, Dissolved	1, 18, 20, 47, 48
	pH	1, 5, 13, 15, 16, 17, 18, 20, 25, 27, 34, 35, 37, 39, 43, 44, 47, 48, 49
	Solids, Total Suspended	1, 11, 13, 16, 17, 22, 25, 26, 27, 29, 34, 35, 37, 40, 43, 44, 47, 48, 50, 51
	Zinc	1, 6, 8, 11, 13, 15, 17, 18, 20, 25, 29, 35, 40, 44, 47, 48, 49, 51

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(1) Criteria which have not been exceeded are not included.
(2) Reach designations are defined on Table 2-2.

Table 3-3 shows two sets of information for primary contact recreation. As discussed in Chapter 2, the local goal and the national goal differ on the number of reaches designated for primary contact recreation. Eight more stream reaches are designated for this use under the national goal than under the local goal. Therefore, fecal coliform criteria for the use are applicable in eight more reaches under the national goal. Because of this difference, eleven reaches have fecal coliform concentrations exceeding criteria for primary contact recreation under the national goal, while only five reaches have concentrations exceeding criteria under the local goal.

It is important to emphasize that the criteria are the same for both goals. The differences between the two goals are caused by the larger number of reaches designated for primary contact recreation under the national goal.

Table 3-3 also shows two sets of information for ammonia under the fishery use classification. To determine un-ionized ammonia concentrations requires concurrent monitoring of total ammonia, pH and temperature. Such concurrent monitoring has seldom been done in the study area. Thus, un-ionized ammonia concentrations have been estimated in two ways: (1) assume that the highest recorded water temperature and pH occurred at the time of sampling for total ammonia and (2) assume that the average temperature and pH occurred at the time of sampling for ammonia. The first method represents worst possible conditions, while the second method represents more likely conditions. As shown on Table 3-3, no un-ionized ammonia excesses occur under the more likely conditions.

Percentage-Of-Time Approach

The percentage-of-time approach has been selected for all constituents associated with chronic, cumulative, or long-term effects. These constituents include--

- Metals, which are not acute toxins at concentrations found in the study area.
- Boron, which is a cumulative poison to crops.
- SAR-TDS, which when in high concentrations in irrigation water, tend to break down soil structure over time and make water less available to crops.
- Total dissolved solids (TDS), which can lead to gall-stones in cattle with prolonged consumption.
- TDS, which is related to increased costs for industry and domestic water uses.
- Total suspended solids, whose eventual deposition can cause a loss of fish habitat.

Also, pH has been included in the chronic category because it strongly affects the ammonia concentrations and solubility of metals.

Under the second interpretation, a water use is considered impaired if the concentrations of a particular constituent exceed the water quality criteria for use a certain percentage of the time. An example of the type of graph used to determine this percentage of time is given on Figure 3-4. As shown in the figure, fecal coliform concentrations in the Lower Green River reach are estimated to remain within the secondary contact recreation criterion 68 percent of the time in the wet period (April-September) and 83 percent of the time in the dry period (October-March).

Two assumptions were made about the water quality data in order to develop a graph like Figure 3-4. The first assumption was that there is a statistically normal distribution for the two populations of water quality data, those obtained during the wet period and those obtained during the dry period. The disparate populations are a result of the different relative importance of surface runoff and ground water to the total streamflow. Surface runoff is a much larger contributor to streamflow and contaminant loadings during the wet period.

A second assumption concerning the water quality data was that sampling frequency was consistent during the wet and dry periods. The x-axis on Figure 3-4 should be labeled strictly the "percentage of samples with a concentration less than y." However, if sampling frequency is consistent during the period, the percentage of samples is approximately equal to the percentage of time. For many of the constituents which have been routinely monitored on a monthly basis, this assumption appears generally valid. However, for constituents such as metals, which have been monitored less consistently, this assumption may not be valid.

Those constituents whose water quality criteria have been exceeded at least one-quarter of the time in at least one reach are listed on Table 3-4. The percentage of time a criterion is exceeded has been rounded to the nearest quarter. For primary contact recreation, secondary contact recreation, and agricultural irrigation, whose criteria apply only to the wet period, the percentage of time refers to that fraction of time during the wet period (April-September) that the criteria are exceeded.

Selected Approach

A comparison of the two interpretations of use impairments on Table 3-5 shows that the second interpretation of water quality may indicate better water quality in the study area than does the first interpretation. For example, the first interpretation yields impairment of fisheries in 29 reaches. The second interpretation shows fishery impairment in only 13 reaches if criteria are to be exceeded less than 50 percent of the time, and 19 reaches if criteria are to be exceeded less than 25 percent of the time.

In this report, a water quality problem is defined as the impairment of an existing or projected water use. Impairment is assumed to occur (1) if a constituent associated with acute effects has exceeded the water quality criterion in any sample, or (2) if a constituent associated with chronic effects exceeds the water quality criterion more than one-half of the time. Information is available in this report to select one-quarter, one-half,

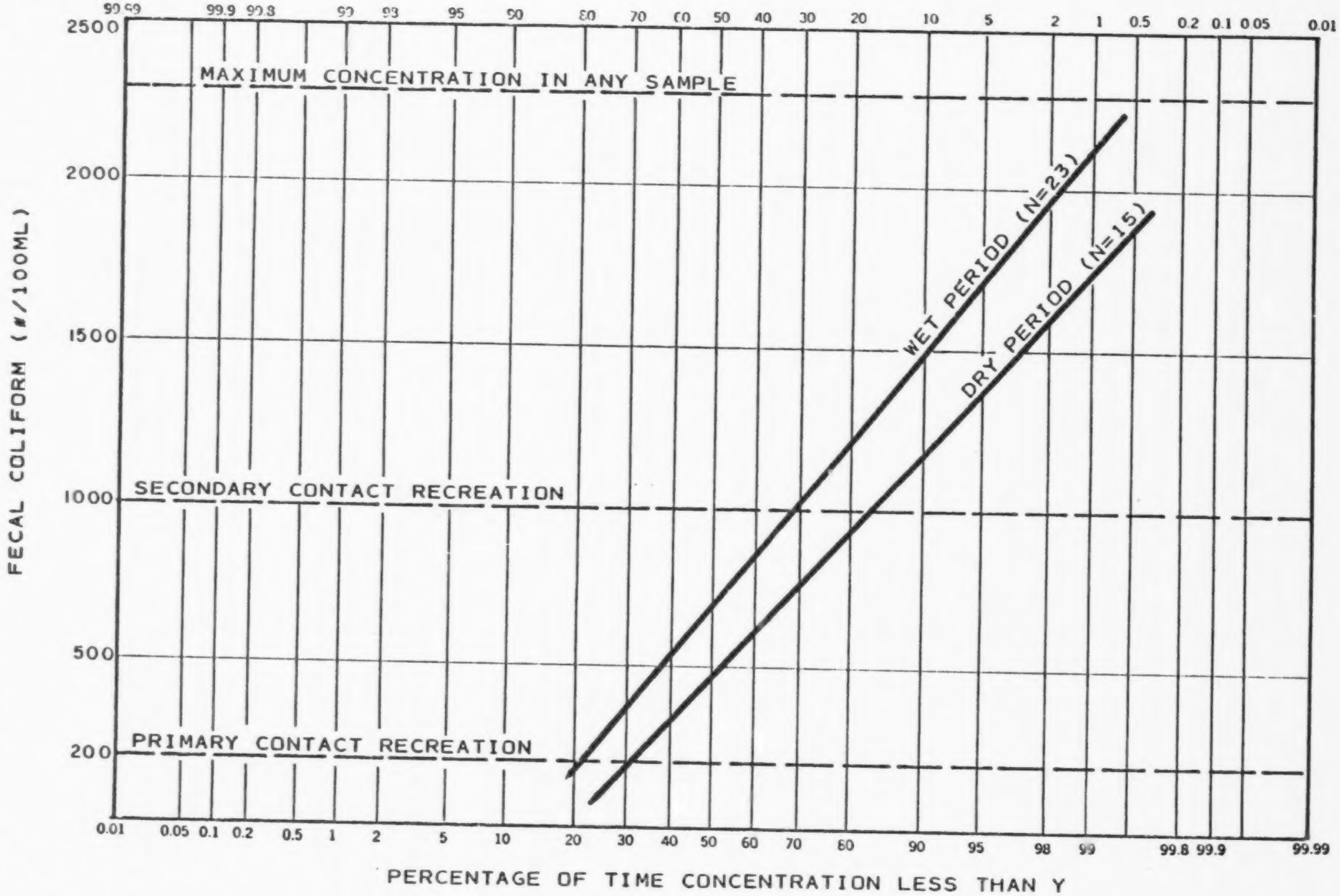


FIGURE 3-4
FECAL COLIFORM CONCENTRATIONS IN THE
LOWER GREEN RIVER REACH (REACH #18)

CH2M HILL

Table 3-4

PERCENTAGE OF TIME CRITERIA ARE EXCEEDED

Use	Exceeded Criterion[1]	Reach
Secondary Contact Recreation	Fecal Coliform	18, 31, 3[illegible], 40, 4[illegible]
Primary Contact Recreation	Fecal Coliform	1[illegible], 55(2), 4[illegible](2)
Stream Aesthetics	None	
Reservoir and Lake Aesthetics	Total Phosphorus	Insufficient number of samples
Industrial Water Supply	Total Dissolved Solids	Criteria not yet developed
Agricultural Irrigation	Boron	40, 47
	SAR-TDS	10, 16, 17, 18, 2[illegible], 27, 2[illegible], 3[illegible], [illegible], 40, 48, [illegible]
Wildlife and Livestock Watering	Chloride	53
	Mercury	1, 43
	Sulfate	29, 53
	Total Dissolved Solids	53
Public Water Supply	Total Dissolved Solids	Criteria not yet developed
	Sulfate	47
Fishery	Ammonia, Un-ionized (worst conditions)	47, 18, 27
	Beryllium	27
	Cadmium	1, 8, 1[illegible], [illegible]
	Copper	8, 15, 17
	Lead	13, 17, 20
	Mercury	1, 13
	pH	1, 17, 18, 27, 43, 49
	Total Suspended Solids	1, 13, 16, 17, 22, 25, 26, 27, 29, 31, 40, 41, 47, 48
	Zinc	1, 8, 8, 15, 17, 20

LEGEND

☐ Reach designations defined on Table 2-2
◰ Criterion exceeded one-quarter of the time
⬒ Criterion exceeded one-half of the time
◩ Criterion exceeded three-quarters of the time
■ Criterion exceeded all the time

---

(1) Criteria which have not been exceeded at least one-quarter of the time are not included.
(2) Applicable only under national goal, where primary contact recreation is a designated use for this reach.

Table 3-5

COMPARISON OF TWO INTERPRETATIONS OF USE IMPAIRMENT

Use	Number of Reaches Showing Use Impairment				
	Interpretation #1	Interpretation #2			
	Maximum Concentration Exceeds Criterion	Concentration Exceeds Criterion			
		1/4 of Time	1/2 of Time	3/4 of Time	All of Time
Secondary Contact Recreation	7	5	4	3	1
Primary Contact Recreation (1)	11	3	2	2	0
Stream Aesthetics	0	0	0	0	0
Reservoir and Lake Aesthetics	7	NSI (2)	NSI (2)	NSI (2)	NSI (2)
Agricultural Irrigation	13	13	7	5	2
Wildlife and Livestock Watering	9	4	1	0	0
Public Water Supply	6	1	0	0	0
Fishery	29	19	13	5.	2

---

(1) Under national goal.
(2) NSI = not sufficient information.

three-quarters, or 100 percent as the evaluation criterion when formulating final plans for constituents associated with chronic effects. One-half has been chosen because the impaired uses given this criterion correspond most closely to the apparent water quality problems in the study area.

SURFACE WATER QUALITY PROBLEMS

Use impairments are shown by reach on Figures 3-5 through 3-13 for the nine water uses in the study area. These figures are located at the end of this chapter. The constituents that exceed the criteria in each case are given on Table 3-6. Many of the uses shown as impaired in this section of the report are presently being exercised without any apparent curtailment of use. Specific instances are discussed under the section for each use. In general, possible reasons for this discrepancy are listed below:

- Certain water quality criteria may be overprotective of the uses. The metal criteria for fisheries may be among these, because the strictest literature criteria were selected in most cases. However, these criteria were based on toxicities to rainbow trout, which is one of the two most common game fish in the study area.
- Water quality data taken at one station may not adequately characterize water quality along the entire length of the reach. All 18 reaches which have two or more water quality stations show some change in water quality along the length of the reach. The biggest changes in water quality within a reach generally occur in the upper reaches of the Green River and Blacks Fork and in the tributaries. However, many of the impaired uses and most of the use of water occur in the lower reaches. Therefore, the changes in water quality within a reach appear relatively unimportant to the measurement of water quality impacts in the study area. The one reach where the change in quality has been identified as being important to adequately measure use impairment is the Upper Big Sandy. This exception is discussed later in the "Agricultural Irrigation" section and noted on Figure 3-10.
- Some of the use impairment is related to chronic effects, whose impact may be only partially realized at the present time or may be subtle, such as lower fish propagation rather than fish kills.

Use impairments and documented water quality problems are identified below for all nine uses in the study area. As shown on Figure 3-2, many reaches do not have enough water quality data to permit identification of all possible use impairments. In a few cases, use impairment in these reaches has been assumed because of supportive water quality data from adjacent reaches. These cases are shown on Figures 3-5 through 3-13, and the reaches involved are designated "assumed use impairment."

Table 3-6

SUMMARY OF USE IMPAIRMENTS FOR SURFACE WATER

Reach[1]	Secondary Contact Recreation	Primary Contact Recreation	Stream Aesthetics	Reservoir and Lake Aesthetics	Industrial Water Supply	Agricultural Irrigation	Livestock and Wildlife Watering	Public Water Supply	Fishery[3]
1									Cd, DO, NH_3, Zn
2									
3									
4									
5				P					
6								TDS	Zn
7									Zn
8				P					Zn
9									
10		FC[2]							
11									Cd
12									
13		FC							Cu, NH_3
14				P					
15		FC							
16		FC			TDS				
17		FC			TDS			TDS, SO_4	Cd, Cu, Pb, Zn, TSS, NH_3
18	FC	FC			TDS				DO, TSS, NH_3
19				P	TDS				DO
20				P				SO_4	DO, Zn
21									
22									
23									
24				P					
25		FC[2]				SAR-TDS			TSS
26									TSS
27						SAR-TDS			Be, pH, TSS, NH_3
28									
29	FC					SAR-TDS	SO_4		TSS, NH_3
30	FC								
31	FC								
32	FC								
33	FC						Cl, SO_4, TDS		
34									
35		FC[2]				SAR-TDS		SO_4	TSS
36		FC[2]				SAR-TDS			
37		FC[2]				SAR-TDS			
38				P	TDS	SAR-TDS			
39									
40	FC					SAR-TDS			
41									
42									
43									TSS, NH_3
44									TSS, NH_3
45									
46				P					
47	FC	FC[2]			TDS			TDS	DO, NH_3
48								TDS, SO_4	DO, NH_3
49									
50									
51						SAR-TDS			NH_3
52									

---

(1) Reach designations on Table 2-2.

(2) Use impairment under the national goal only.

(3) Impairments with respect to ammonia reflect worst possible conditions.

Symbols

Ammonia	NH_3
Beryllium	Be
Cadmium	Cd
Chloride	Cl
Coliform, Fecal	FC
Copper	Cu
Lead	Pb
Oxygen, Dissolved	DO
Phosphorus, Total	P
Sodium Adsorption Ratio	SAR
Solids, Total Dissolved	TDS
Solids, Total Suspended	TSS
Sulfate	SO_4
Zinc	Zn

Secondary Contact Recreation

Impairment of secondary contact recreation in the study area is a result of high fecal coliform concentrations. Impairment is indicated in eight reaches within the study area. Five of these are in the Bitter Creek drainage: a sixth reach is Lower Green River, directly below the confluence of the Green River and Bitter Creek. The other two reaches are Lower Smiths Fork and Middle Hams Fork.

As noted earlier in this chapter, violations of the fecal coliform standard have been documented by DEQ in the 305(B) report for 1976. These violations have occurred in the four reaches of Killpecker Creek, Lower Bitter Creek, Lower Green River, and Middle Hams Fork.

Primary Contact Recreation

Impairment of primary contact recreation is indicated in five reaches under the locally generated goal and in eleven reaches under the national goal. Under the local goal, all use impairments are shown along the mainstream of the Green River. Under the national goal, use impairments are also shown for the Border reach of the Bear River, the Upper Big Sandy reach, three reaches on the Blacks Fork, and Middle Hams Fork.

DEQ has documented the fecal coliform violation in the Lower Green River reach (#18). This reach contains several popular swimming locations.

Stream Aesthetics

No impairment of stream aesthetics has been documented from the limited water quality information. The aesthetic value of the Green River between the Sublette-Sweetwater county line and Big Island is considered to be high, according to a report by the Wyoming Water Resources Research Institute. However, concern has been expressed in public meetings held by SWWQPA about excessive algal growth in the lower reaches of Blacks Fork and about trash and garbage along the banks of Bitter Creek as it flows through Rock Springs.

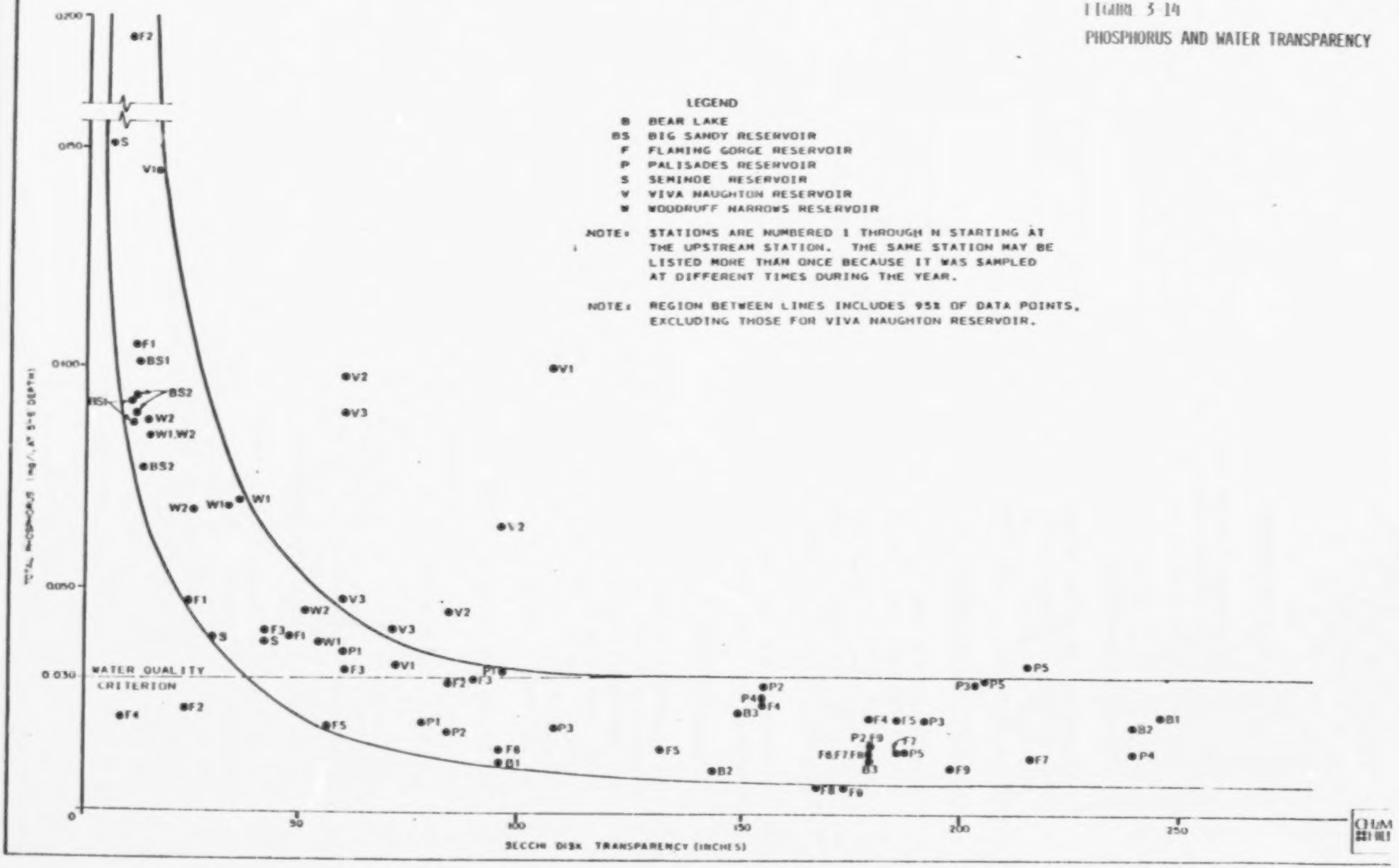
Reservoir and Lake Aesthetics

Impairment of reservoir and lake aesthetics is indicated in all water bodies except Bear Lake, which is located just west of the Wyoming-Idaho line. As shown on Figure 3-14, repeated from Figure 2-5, phosphorus concentrations at 5 to 6 feet below the surface exceed the phosphorus criterion of 0.030 mg/l at one or more stations in all reservoirs and lakes except Bear Lake. The graph shows the close relationship between phosphorus and aesthetics, as measured by water transparency, for all reservoirs and lakes in the region except Viva Naughton.

The graph also shows that impairment is generally more common in the upstream reaches of a reservoir. For example, impairment is indicated in the Green River Arm (Station F1) of Flaming Gorge, in the Blacks Fork Arm (F2), and just below the confluence of the two arms (F3). No impairment occurs at the other Wyoming stations (F4 and F5) or the Utah stations (F6 through F9) in Flaming Gorge.

FIGURE 3-14

PHOSPHORUS AND WATER TRANSPARENCY



LEGEND

B BEAR LAKE
BS BIG SANDY RESERVOIR
F FLAMING GORGE RESERVOIR
P PALISADES RESERVOIR
S SEMINOE RESERVOIR
V VIVA NAUGHTON RESERVOIR
W WOODRUFF NARROWS RESERVOIR

NOTE: STATIONS ARE NUMBERED 1 THROUGH N STARTING AT THE UPSTREAM STATION. THE SAME STATION MAY BE LISTED MORE THAN ONCE BECAUSE IT WAS SAMPLED AT DIFFERENT TIMES DURING THE YEAR.

NOTE: REGION BETWEEN LINES INCLUDES 95% OF DATA POINTS, EXCLUDING THOSE FOR VIVA NAUGHTON RESERVOIR.

The Environmental Protection Agency (EPA) has conducted eutrophication surveys on five reservoirs in the study area and on Bear Lake. The trophic status of each water body and the factors limiting algal and weed growth during the summer and fall are presented on Table 3-7. Conditions in the lake and reservoirs span the spectrum from under-productive, fish-poor Bear Lake to algae-clogged Woodruff Narrows. The three most important bodies for recreation-- Bear Lake, Flaming Gorge, and Palisades--are all phosphorus limited or co-limited. All reservoirs designated eutrophic by EPA have phosphorus concentrations at 5 to 6 feet below the surface which exceed the phosphorus criterion.

Eutrophication can have impacts in the study area beyond aesthetics. Possible impacts include a shift from game to nongame species in Flaming Gorge Reservoir and impaired boating and fishing due to weeds snagging propellers and fishing gear.

Industrial Water Supply

Industrial use impairment is shown on Figure 3-9 for six reaches. In these reaches, industrial consumption of water is high and potential industrial benefits from salinity control are great. Four of the reaches are along the mainstem of the Green River below the Big Sandy River, and the other two are on the Hams Fork and Blacks Fork.

Agricultural Irrigation

Impairment of agricultural use of water for irrigation is indicated in nine reaches within the study area. Five of these reaches are located in the Blacks Fork drainage. Although impairment is shown in the Upper Big Sandy reach, crop production has not appeared to be adversely affected in the reach. An impairment is indicated on the basis of the data because the sampling station is located below almost all of the irrigated acreage in the reach and is measuring high TDS values, probably as a result of the irrigation activities. The water used for irrigation in this reach, however, is diverted at the extreme upper end of the reach where there are no data to evaluate its suitability for agricultural irrigation.

High total dissolved solids concentrations are the reason for agricultural impairment in all cases. Sodium adsorption ratios are well below critical levels in all reaches except Upper Bitter Creek and Lower Smiths Fork.

Although the data used in this study indicate an agricultural use impairment, curtailment of irrigation activities due to use of surface water has not been observed. It may be that flood irrigation in spring, which is a common practice in all the reaches designated as impaired by this report, leaches out salts which have accumulated over the previous irrigation season.

Wildlife and Livestock Watering

Impairment of wildlife and livestock watering is indicated in two reaches, both in the Bitter Creek drainage. Impairment is a result of high chloride, sulfate, and total dissolved solids concentrations.

Table 3-7

EUTROPHICATION OF LAKES AND RESERVOIRS IN STUDY AREA

Lake or Reservoir	Trophic Status (1)	Limiting Factor (1)
Bear Lake	Oligotrophic	Phosphorus, Nitrogen
Big Sandy	Eutrophic	Turbidity
Flaming Gorge	Eutrophic in Wyoming, Mesotrophic in Utah	Phosphorus
Fontenelle	-	-
Palisades	Mesotrophic	Phosphorus, Nitrogen
Viva Naughton	Eutrophic	Nitrogen
Woodruff Narrows	Eutrophic	Nitrogen

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(1) From draft reports, EPA National Eutrophication Survey.

Public Water Supply

Impairment of public water supplies is indicated in seven reaches. High sulfate concentrations are the reason for impairment in the Green River reach, from which the Rock Springs-Green River area obtains its water. Sulfate is also the cause of use impairment in Flaming Gorge, Lower Hams Fork and the Lyman reach, while radioactivity is the cause in the Lower Smiths Fork reach. Total dissolved solids are indicated on Table 3-6 as a major economic concern in four reaches.

DEQ documented several violations of the 1962 U.S. Public Health Service drinking water standards in 1975 and 1976. Lead concentrations in the Green River near LaBarge and mercury concentrations in the Green River below Fontenelle Dam exceeded the respective standards. Violations in 1975 and 1976 of the iron and manganese standards, which are not included in the latest National Interim Primary Drinking Water Regulations, were widespread throughout the study area. All violations were attributed to natural causes.

DEQ also noted that radioactivity in the Smiths Fork near Lyman exceeded the recommended levels stated in the National Interim Primary Drinking Water Regulations. The violation was attributed to natural erosion of Wyoming's moderately abundant radioactive soils.

Laxative effects from high sulfate water have been experienced by visitors to the Rock Springs-Green River area during 1977. No other adverse health effects have been attributed to drinking water quality in the study area.

Figure 3-12 shows impairment of public water supplies due to only health and aesthetics impacts. Additional impairment occurs because of the economic impacts of hardness in the water. This impairment is discussed in Chapter 4.

Fisheries

Impairment is indicated on 20 reaches within the study area. Several of these reaches are considered "blue-ribbon" fisheries by the Wyoming Game and Fish Department. Possible reasons for this disparity are discussed below.

Many of the use impairments are attributed in part to excessive concentrations of un-ionized ammonia. As noted earlier in this chapter, assumptions concerning pH and temperature had to be made in order to calculate un-ionized ammonia concentrations from the water quality data on total ammonia. The earlier discussion showed that ammonia excesses were unlikely to have occurred unless pH and temperature were extremely high at the time of sampling. Therefore, the ammonia information presented on Table 3-6 should be taken not as actual ammonia excesses but rather as indicators where further monitoring should be done in order to define if excessive amounts of ammonia are present in the streams.

Two other constituents shown to cause widespread fishery impairments are total suspended solids and heavy metals. As noted in Chapter 2, there is considerable uncertainty about the proper criteria for these constituents necessary to protect fisheries in the study area. The criteria used in this study may be overprotective. Because of the uncertainty about criteria levels and the absence of any documented evidence in the study area relating fisheries impairments to excessive concentrations of suspended solids or heavy metals, it is unlikely that control programs for these constituents would be acceptable.

A fish kill occurred in 1975 in the headwaters of the Big Sandy River. The location of the kill is outside of the study area. No reasons were found by DEQ for the kill.

Changes in fish population in Flaming Gorge Reservoir from game to nongame fish are described in the next chapter. These changes may be attributed to secondary effects of eutrophication.

The literature mentions low temperatures and turbidity in the mainstem of the Green River as potential causes of game fish population reductions. However, no changes in game fish populations have been correlated with either temperature or turbidity.

SUMMARY OF SURFACE WATER QUALITY

Table 3-6 shows the use impairments based on a strict application of the criteria developed in Chapter 2. As noted earlier, many of the uses shown as impaired are presently being exercised with no apparent use impairment. Several possibilities have been advanced to explain this discrepancy: certain criteria may incorrectly identify use impairments; water quality data taken at one station in a reach may not characterize water quality at the point in the reach where the use is actually exercised; and use impairments may be so subtle so as not to be readily apparent. For these reasons, some of the use impairments shown on Table 3-6 may not actually exist.

The goal of the 208 planning process in Southwestern Wyoming is an implementable program of water quality management. Therefore, the water quality management plan will focus on the more obvious and what appear to be the more serious water quality problems in the study area. Those water quality problems emphasized in the plan are noted on Table 3-8. Other constituents shown on Table 3-6, such as ammonia and total suspended solids, will also be addressed in the plan but in less detail.

GROUND WATER PROBLEMS

The primary uses of ground water in the study area are for domestic and livestock consumption. Domestic consumption of ground water in excess of the sulfate criterion of 250 mg/l is common in Sweetwater County. Livestock consumption of ground water in excess of the TDS, sulfate, and chloride criteria occurs in the eastern part of the county. The high TDS, sulfate, and chloride concentration are caused by leaching from the saline formations underlying many sections of the county.

Table 3-8

SUMMARY OF MAJOR SURFACE WATER QUALITY PROBLEMS

Use	Constituent	Reach with Water Quality Problems
Secondary Contact Recreation	Fecal Coliform	Lower Green River (#18) Bitter Creek (#29, #30, #31) Salt Wells Creek (#32) Killpecker Creek (#33) Lower Smiths Fork (#40) Middle Hams Fork (#47)
Primary Contact Recreation	Fecal Coliform	Bear River, Border Reach (#10) (1) Green River (#13, #15, #16, #17, #18) Upper Big Sandy (#25) (1) Blacks Fork, Lyman to Little America (#35, #36, #37) (1) Middle Hams Fork (#47) (1)
Stream Aesthetics	Litter	Lower Bitter Creek (#31)
Reservoir and Lake Aesthetics	Phosphorus	Flaming Gorge Reservoir (#19, #20, #38)
Industrial Water Supply	Total Dissolved Solids	Green River, Big Island Reach to Green River Arm (#16, #17, #18, #19) Blacks Fork Arm (#38) Middle Hams Fork (#47)
Agricultural Irrigation	SAR-TDS	None given present practices
Livestock and Wildlife Watering	Chloride	Killpecker Creek (#33)
	Sulfate	Upper Bitter Creek (#29) Killpecker Creek (#33)
	Total Dissolved Solids	Killpecker Creek (#33)
Public Water Supply	Sulfate	Green River Reach (#17) Flaming Gorge Reservoir (#20) Lyman Reach (#35) Lower Hams Fork (#48)
	Total Dissolved Solids	Green River Reach (#17)
Fishery	Oxygen, Dissolved	Snake River (#1) Green River, Lower Reach to Reservoir (#18, #19, #20) Hams Fork, Middle and Lower (#47, #48)

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(1) Under national goal only.

Fecal coliform and nitrate concentrations commonly exceed the criteria for ground water in the Bridger Valley. Because of the shallow alluvium in this area, wells are usually less than 40 feet deep and are too close to leach fields and barnyards. Instances of well contamination have become more numerous recently because subdivisions have increased rural housing densities. Step 1 Facility Plans for community wastewater treatment systems have been prepared to alleviate the contamination problem. Moreover, Mountain View and Lyman are abandoning wells and currently building a joint community water system to be supplied from the Meeks Cabin Reservoir.

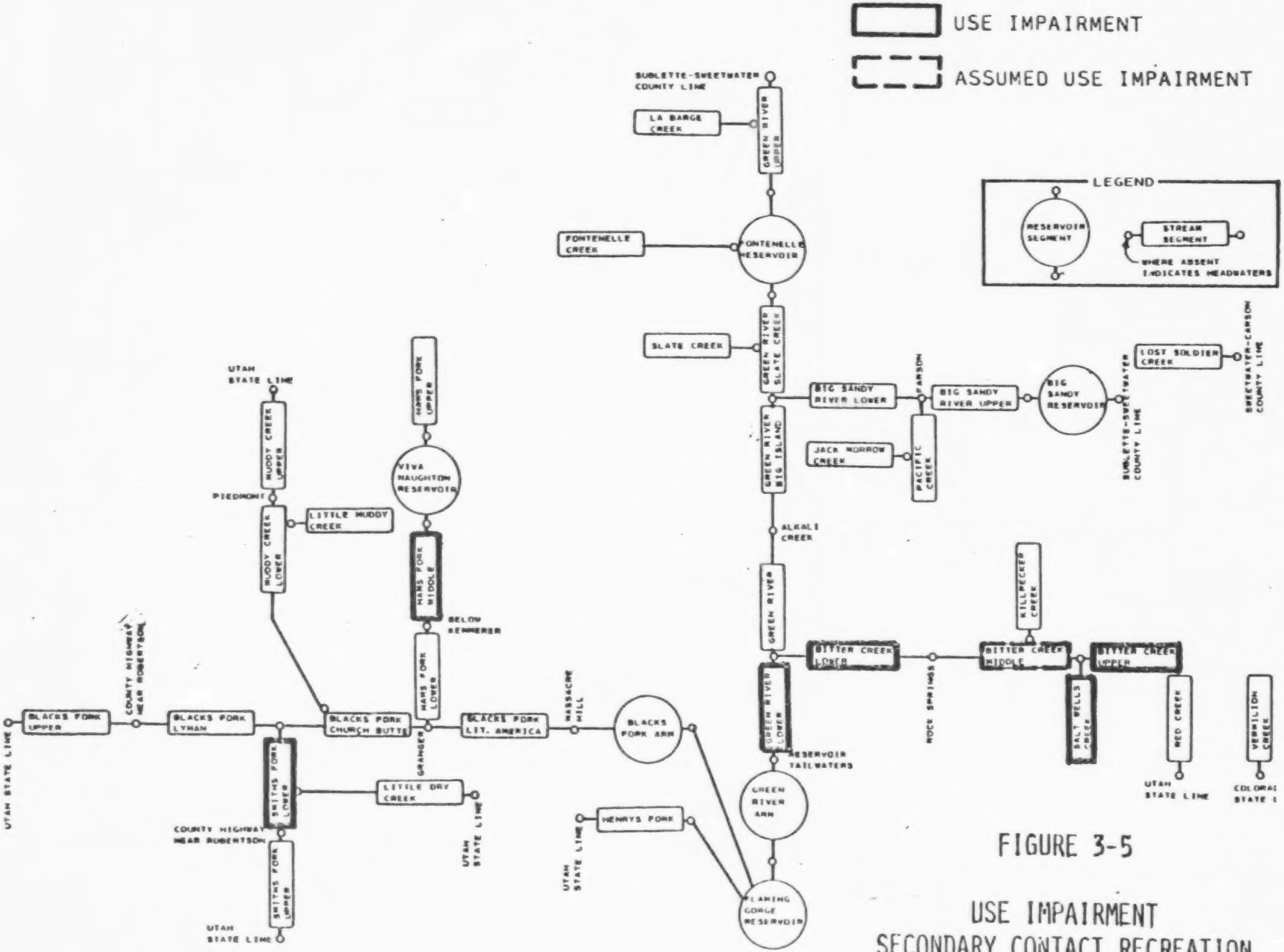
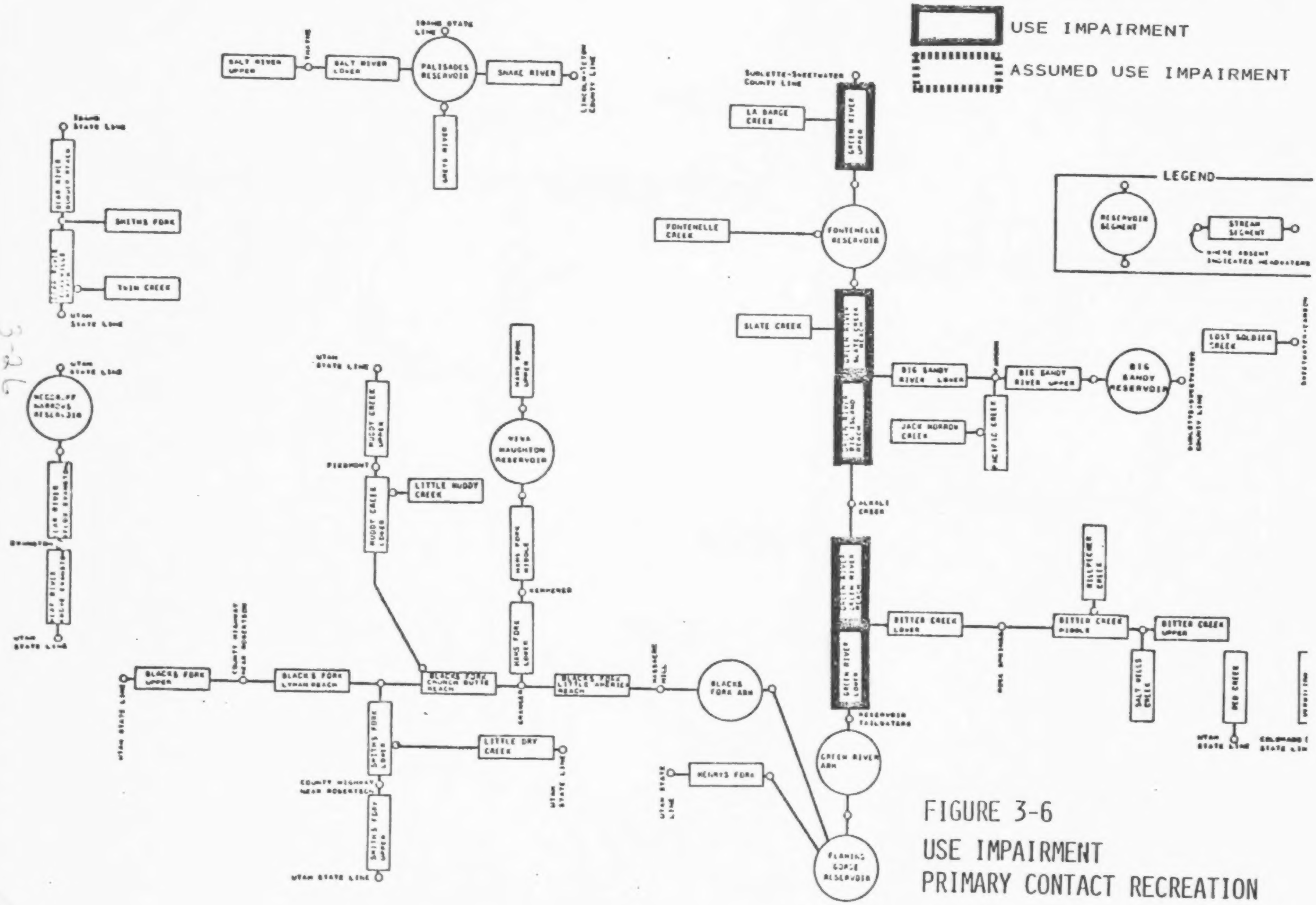

USE IMPAIRMENT
ASSUMED USE IMPAIRMENT
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
SUBLETTE-SWEETWATER COUNTY LINE
GREEN RIVER UPPER
LA BARGE CREEK
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
GREEN RIVER BIG ISLAND
JACK MORROW CREEK
PACIFIC CREEK
ALKALI CREEK
GREEN RIVER
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
VERMILION CREEK
COLORADO STATE LINE
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
BLACKS FORK ARM
HENRYS FORK
UTAH STATE LINE
MASSACRE HILL
BLACKS FORK LIT. AMERICA
GRANGER
HAMS FORK LOWER
BELOW KEMMERER
HAMS FORK MIDDLE
VIVA NAUGHTON RESERVOIR
HAMS FORK UPPER
BLACKS FORK CHURCH BUTTE
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
PIEDMONT
MUDDY CREEK UPPER
UTAH STATE LINE
LITTLE DRY CREEK
UTAH STATE LINE
SMITHS FORK LOWER
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
BLACKS FORK LYMAN
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK UPPER
UTAH STATE LINE

FIGURE 3-5

USE IMPAIRMENT
SECONDARY CONTACT RECREATION


USE IMPAIRMENT
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SALT RIVER LOWER
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
SMITHS FORK
TWIN CREEK
UTAH STATE LINE
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER UPPER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK REACH
BIG SANDY RIVER LOWER
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
LOST SOLDIER CREEK
JACK MORROW CREEK
PACIFIC CREEK
GREEN RIVER BIG ISLAND REACH
ALKALI CREEK
GREEN RIVER LOWER
RESERVOIR TAILWATERS
BITTER CREEK LOWER
BITTER CREEK MIDDLE
BITTER CREEK UPPER
KILLPECKER CREEK
SALT WELLS CREEK
RED CREEK
COLORADO STATE LINE
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
BLACKS FORK ARM
MASSACRE HILL
BLACKS FORK LITTLE AMERICA REACH
BLACKS FORK CHURCH BUTTE REACH
BLACKS FORK LYMAN REACH
BLACKS FORK UPPER
COUNTY HIGHWAY NEAR ROBERTSON
HAMS FORK LOWER
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HAMS FORK UPPER
KEMMERER
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VIVA NAUGHTON RESERVOIR
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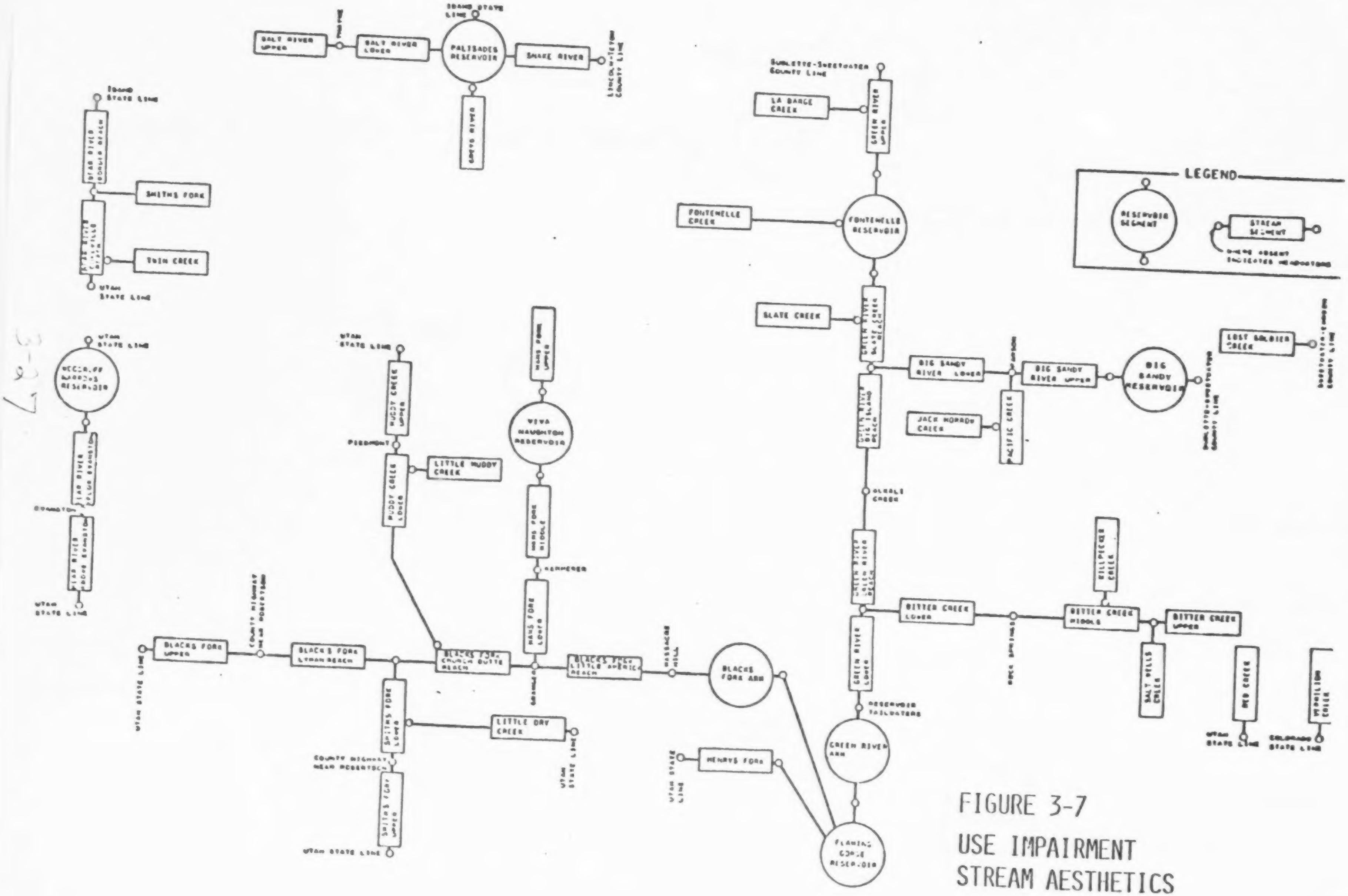
MUDDY CREEK UPPER
LITTLE MUDDY CREEK
PIEDMONT
SMITHS FORK LOWER
SMITHS FORK UPPER
LITTLE DRY CREEK
WOODRUFF NARROWS RESERVOIR
EVANSTON

FIGURE 3-6
USE IMPAIRMENT
PRIMARY CONTACT RECREATION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BEAR RIVER BORDER REACH
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WOODRUFF NARROWS RESERVOIR
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UTAH STATE LINE
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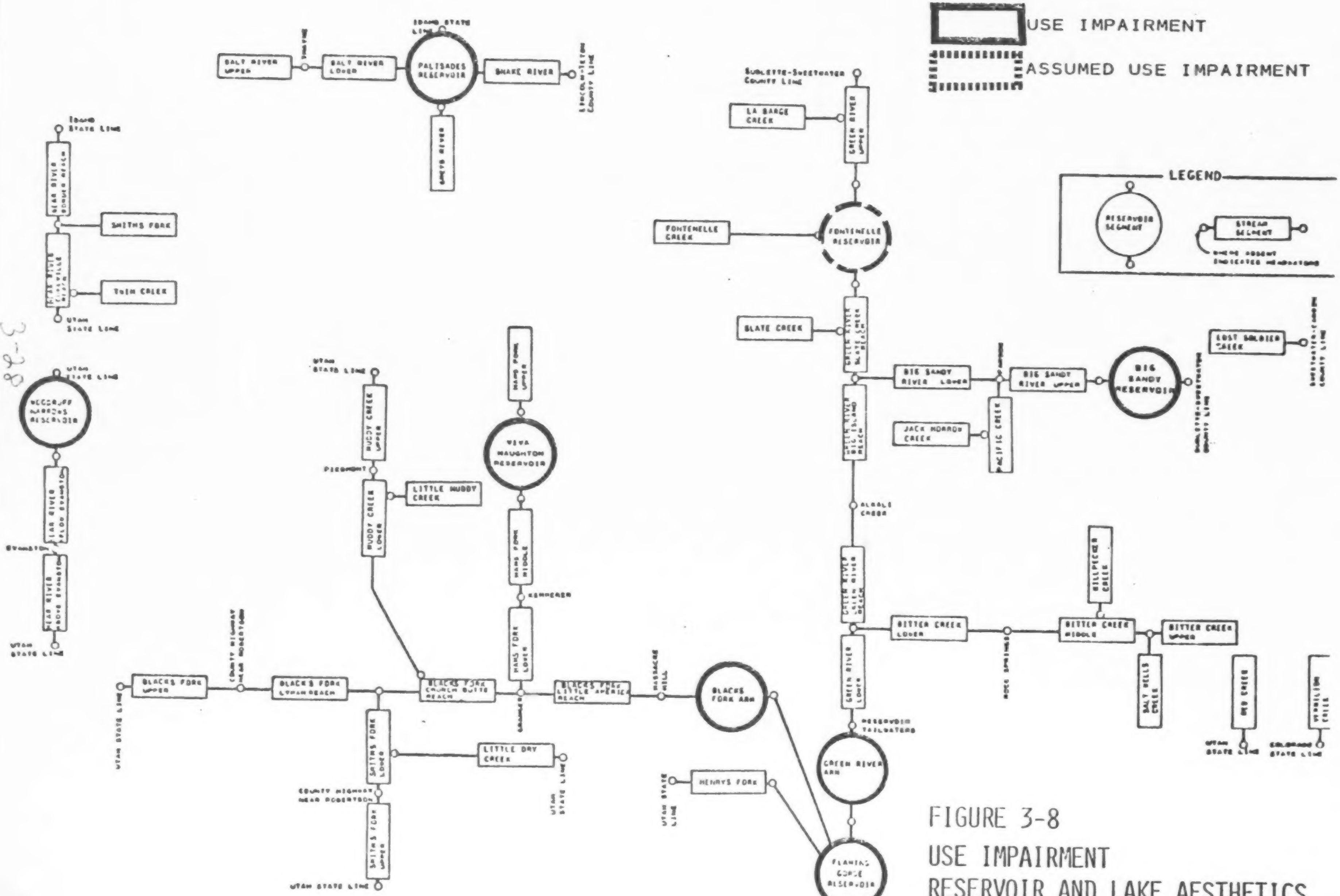
UTAH STATE LINE
SMITHS FORK LOWER
LITTLE DRY CREEK
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE

FIGURE 3-7

USE IMPAIRMENT
STREAM AESTHETICS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UTAH STATE LINE
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MASSACRE HILL
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LITTLE DRY CREEK
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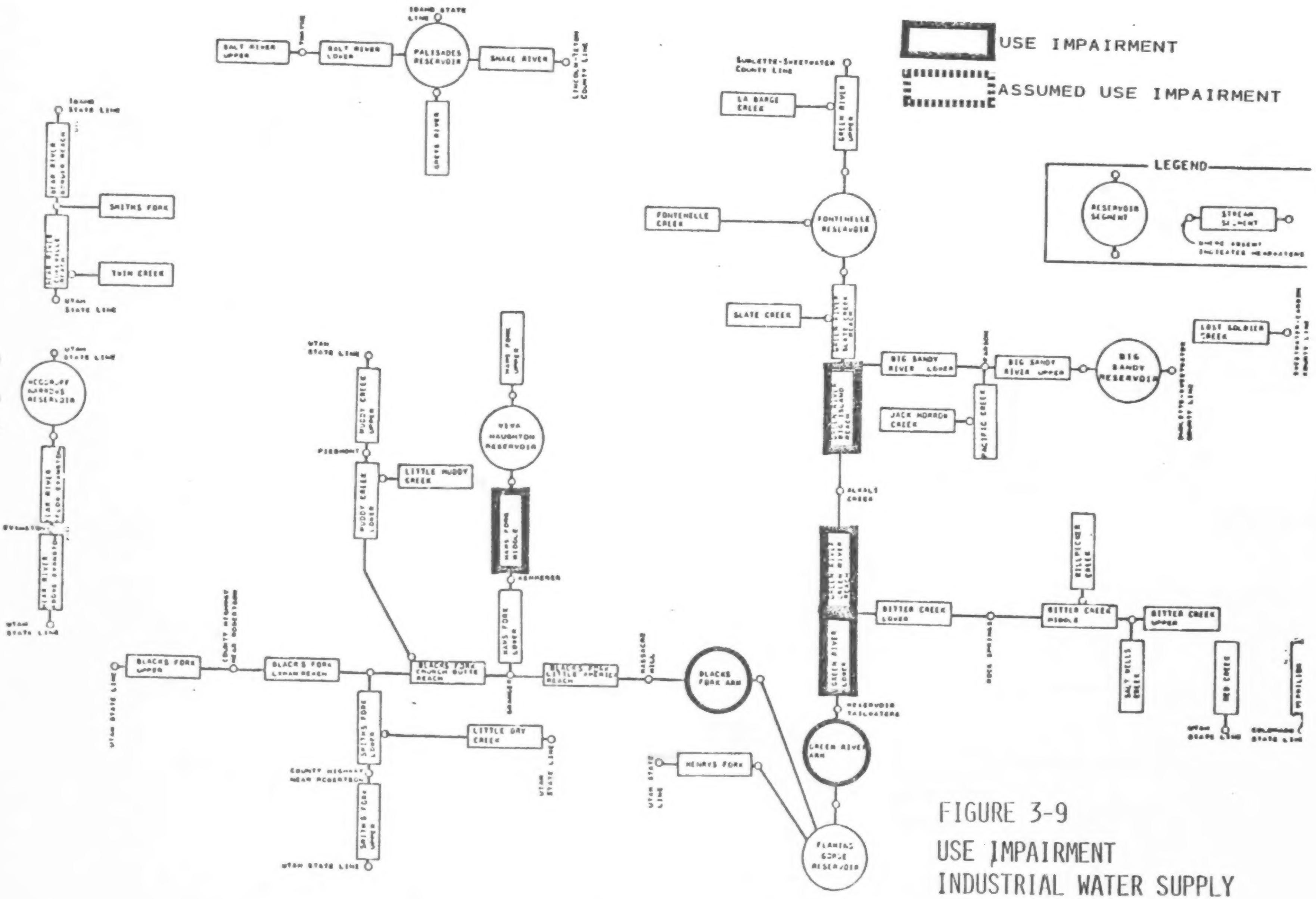
UTAH STATE LINE

FIGURE 3-8
USE IMPAIRMENT
RESERVOIR AND LAKE AESTHETICS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IDAHO STATE LINE
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BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
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JACK MORROW CREEK
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ALKALI CREEK
GREEN RIVER
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GRANGER
HAMS FORK LOWER
KEMMERER
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VIVA NAUGHTON RESERVOIR
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PIEDMONT
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LITTLE DRY CREEK
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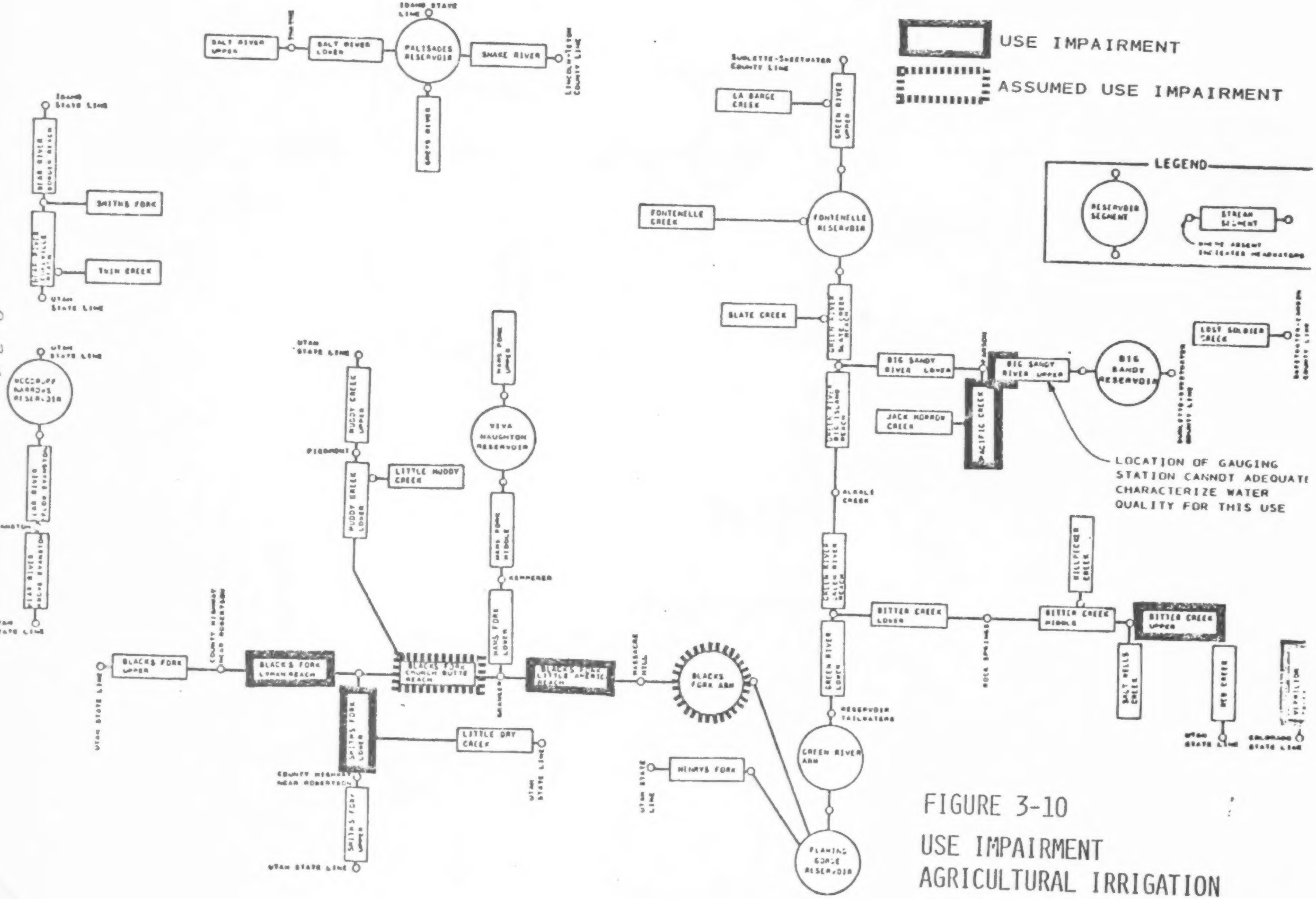
UTAH STATE LINE

FIGURE 3-9
USE IMPAIRMENT
INDUSTRIAL WATER SUPPLY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STREAM SEGMENT
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SALT RIVER LOWER
IDAHO STATE LINE
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
IDAHO STATE LINE
BEAR RIVER BORDER REACH
SMITHS FORK
TWIN CREEK
UTAH STATE LINE
WOODRUFF NARROWS RESERVOIR
UTAH STATE LINE
BEAR RIVER
EVANSTON
BEAR RIVER
UTAH STATE LINE
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER UPPER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK REACH
BIG SANDY RIVER LOWER
BIG SANDY RIVER UPPER
FARSON
BIG SANDY RESERVOIR
LOST SOLDIER CREEK
JACK MORROW CREEK
PACIFIC CREEK
GREEN RIVER BIG ISLAND REACH
ALKALI CREEK
LOCATION OF GAUGING STATION CANNOT ADEQUATE CHARACTERIZE WATER QUALITY FOR THIS USE
GREEN RIVER GREEN RIVER REACH
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
VERMILLION
COLORADO STATE LINE
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
UTAH STATE LINE
BLACKS FORK ARM
MASSACRE HILL
BLACKS FORK LITTLE AMERICA REACH
GRANGER
HAMS FORK LOWER
KEMMERER
HAMS FORK MIDDLE
VIVA NAUGHTON RESERVOIR
HAMS FORK UPPER
BLACKS FORK CHURCH BUTTE REACH
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
PIEDMONT
MUDDY CREEK UPPER
UTAH STATE LINE
BLACKS FORK UPPER
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK LYMAN REACH
SMITHS FORK LOWER
LITTLE DRY CREEK
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE

FIGURE 3-10
USE IMPAIRMENT
AGRICULTURAL IRRIGATION

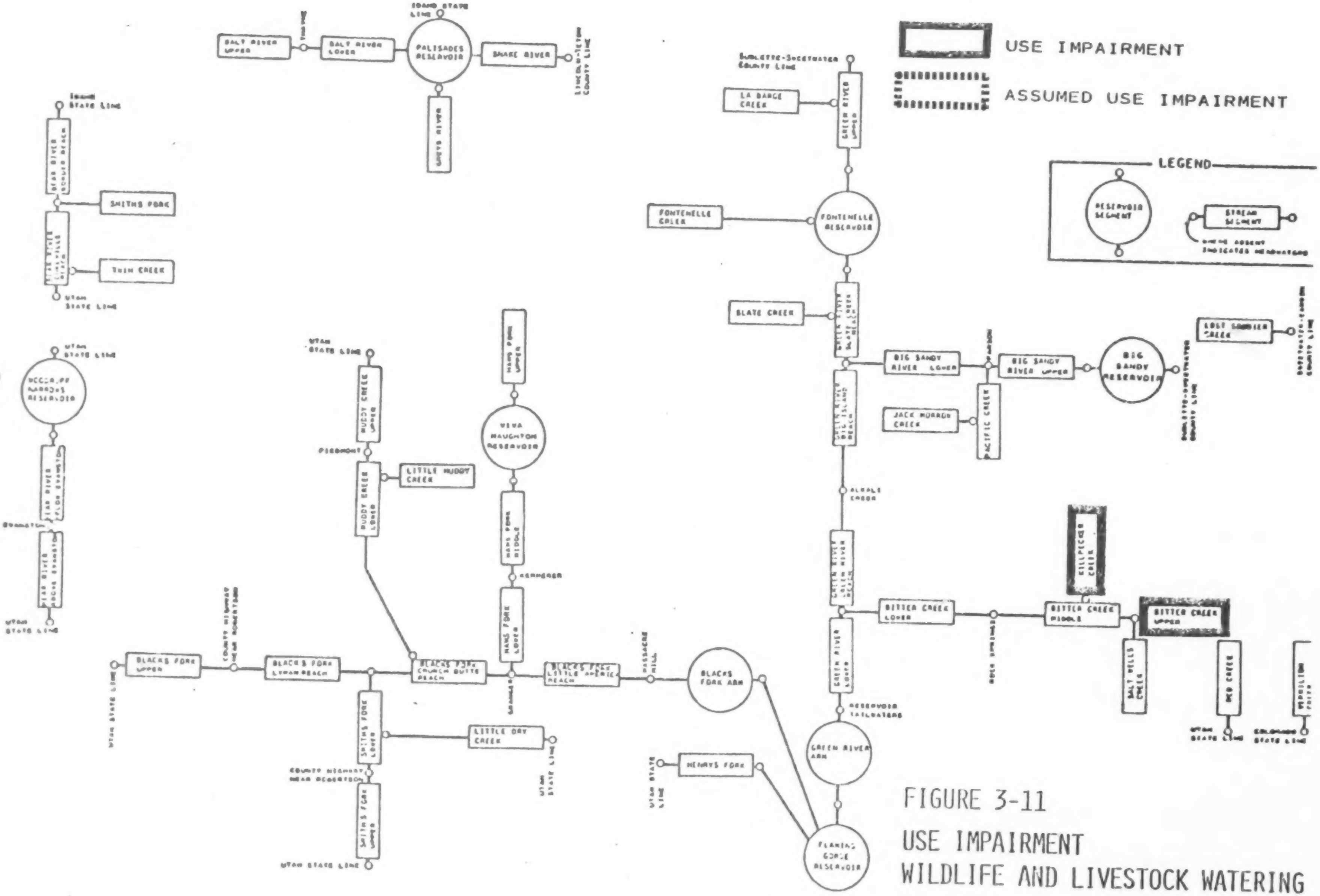

USE IMPAIRMENT
ASSUMED USE IMPAIRMENT
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
CIRCLE ABSENT INDICATES HEADWATERS
SALT RIVER UPPER
SALT RIVER LOWER
IDAHO STATE LINE
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
IDAHO STATE LINE
BEAR RIVER BORDER REACH
SMITHS FORK
TWIN CREEK
UTAH STATE LINE
UTAH STATE LINE
WOODRUFF NARROWS RESERVOIR
BEAR RIVER
EVANSTON
BEAR RIVER
UTAH STATE LINE
UTAH STATE LINE
MUDDY CREEK UPPER
PIEDMONT
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
HAMS FORK UPPER
VIVA NAUGHTON RESERVOIR
HAMS FORK MIDDLE
KEMMERER
HAMS FORK LOWER
BLACKS FORK UPPER
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK LYMAN REACH
BLACKS FORK CHURCH BUTTE REACH
GRANGER
BLACKS FORK LITTLE AMERICA REACH
MASSACRE HILL
BLACKS FORK ARM
SMITHS FORK LOWER
LITTLE DRY CREEK
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
SUBLETTE-SWEETWATER COUNTY LINE
GREEN RIVER UPPER
LA BARGE CREEK
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK REACH
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
GREEN RIVER BIG ISLAND REACH
JACK MORROW CREEK
PACIFIC CREEK
ALKALI CREEK
GREEN RIVER LOWER
KILLPECKER CREEK
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
VERMILION CREEK
COLORADO STATE LINE
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
HENRYS FORK
UTAH STATE LINE
FLAMING GORGE RESERVOIR

FIGURE 3-11

USE IMPAIRMENT
WILDLIFE AND LIVESTOCK WATERING

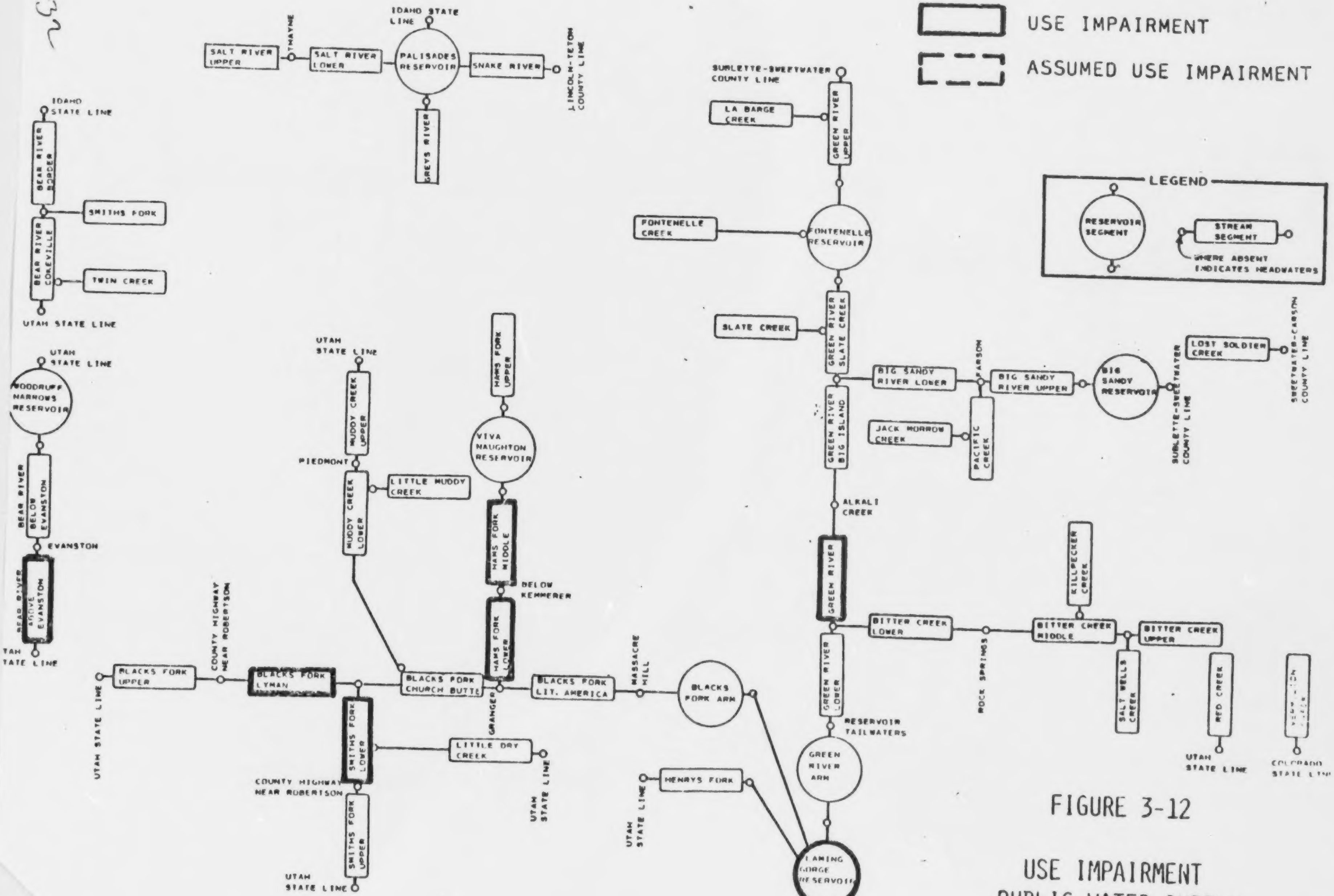

USE IMPAIRMENT
ASSUMED USE IMPAIRMENT
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
IDAHO STATE LINE
BEAR RIVER BORDER
SMITHS FORK
BEAR RIVER COKEVILLE
TWIN CREEK
UTAH STATE LINE
SALT RIVER UPPER
THAYNE
SALT RIVER LOWER
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
WOODRUFF NARROWS RESERVOIR
BEAR RIVER BELOW EVANSTON
EVANSTON
BEAR RIVER ABOVE EVANSTON
UTAH STATE LINE
BLACKS FORK UPPER
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK LYMAN
SMITHS FORK LOWER
SMITHS FORK UPPER
LITTLE DRY CREEK
MUDDY CREEK UPPER
PIEDMONT
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
BLACKS FORK CHURCH BUTTE
GRANGER
HAMS FORK UPPER
VIVA NAUGHTON RESERVOIR
HAMS FORK MIDDLE
BELOW KEMMERER
HAMS FORK LOWER
BLACKS FORK LIT. AMERICA
MASSACRE HILL
BLACKS FORK ARM
HENRYS FORK
FLAMING GORGE RESERVOIR
GREEN RIVER ARM
RESERVOIR TAILWATERS
GREEN RIVER LOWER
GREEN RIVER
ALKALI CREEK
GREEN RIVER BIG ISLAND
GREEN RIVER SLATE CREEK
SLATE CREEK
FONTENELLE RESERVOIR
FONTENELLE CREEK
GREEN RIVER UPPER
LA BARGE CREEK
SUBLETTE-SWEETWATER COUNTY LINE
BIG SANDY RIVER LOWER
FARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
PACIFIC CREEK
JACK MORROW CREEK
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
KILLPECKER CREEK
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
COLORADO STATE LINE

FIGURE 3-12

USE IMPAIRMENT
PUBLIC WATER SUPPLY

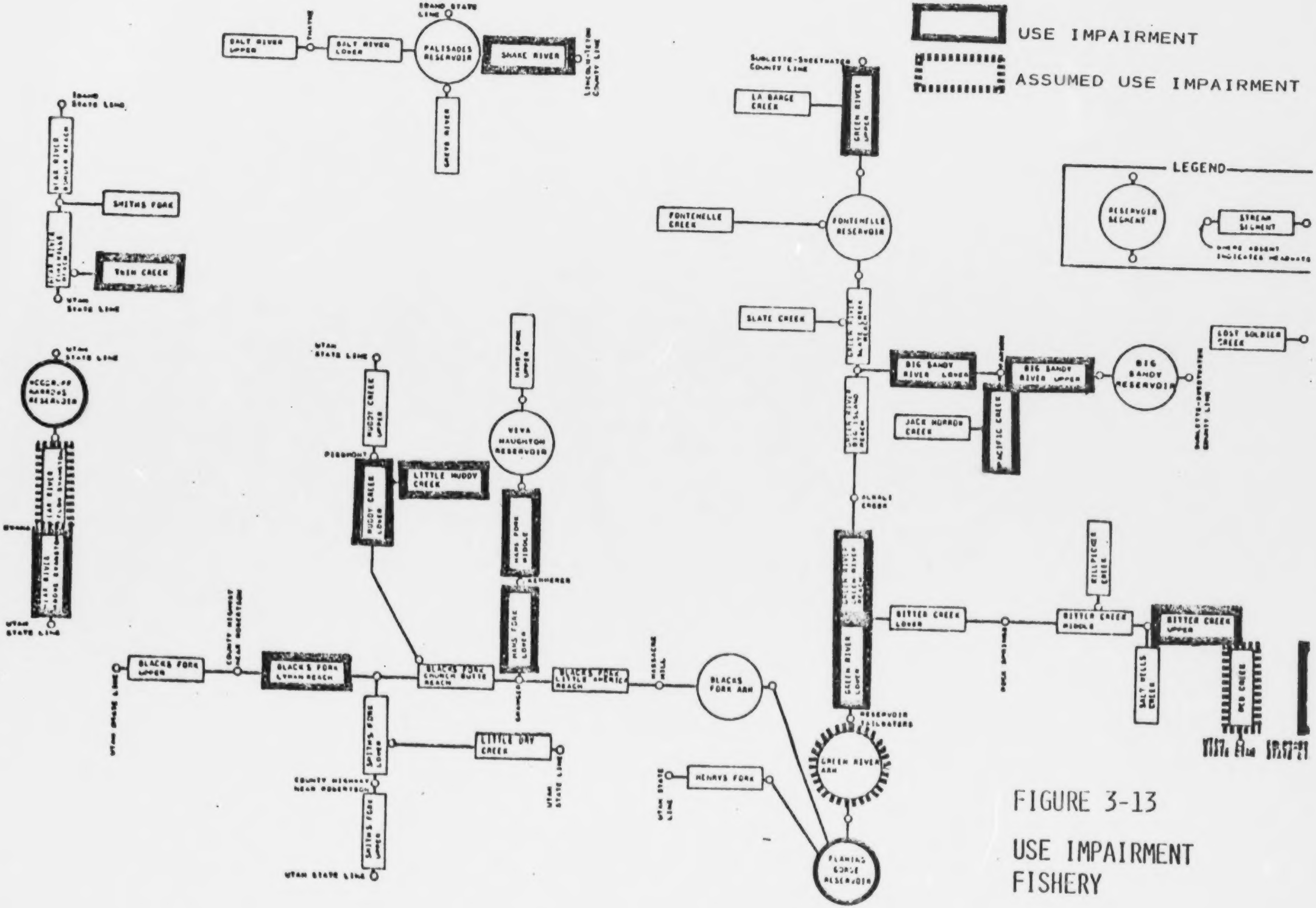

USE IMPAIRMENT
ASSUMED USE IMPAIRMENT
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
SALT RIVER UPPER
THAYNE
SALT RIVER LOWER
IDAHO STATE LINE
PALISADES RESERVOIR
SNAKE RIVER
LINCOLN-TETON COUNTY LINE
GREYS RIVER
IDAHO STATE LINE
SMITHS FORK
TWIN CREEK
UTAH STATE LINE
UTAH STATE LINE
UTAH STATE LINE
MUDDY CREEK UPPER
PIEDMONT
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
HAMS FORK UPPER
VIVA NAUGHTON RESERVOIR
HAMS FORK MIDDLE
KEMMERER
HAMS FORK LOWER
UTAH STATE LINE
BLACKS FORK UPPER
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK LYMAN REACH
BLACKS FORK CHURCH BUTTE REACH
BLACKS FORK LITTLE AMERICA REACH
GRANGER
SMITHS FORK LOWER
LITTLE DRY CREEK
UTAH STATE LINE
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
MASSACRE HILL
BLACKS FORK ARM
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER UPPER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
BIG SANDY RIVER LOWER
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
JACK MORROW CREEK
PACIFIC CREEK
ALKALI CREEK
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
BITTER CREEK LOWER
ROCK SPRINGS
KILLPECKER CREEK
BITTER CREEK MIDDLE
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
HENRYS FORK
UTAH STATE LINE
FLAMING GORGE RESERVOIR

FIGURE 3-13

USE IMPAIRMENT
FISHERY

3-33

Chapter 4
ECONOMICS OF USE IMPAIRMENT

Poor water quality can result in a monetary cost to the users of the water. In this 208 Plan, for instance, an actual dollar value in costs to water users can be associated with use impairment due to salinity and eutrophication. This chapter describes some of the costs that may be anticipated with various salinity and eutrophication levels.

DEFINITION OF SALINITY

Salinity is usually considered to be the sum of all the dissolved salts in water, which is analytically defined as total dissolved solids. This sum may also be measured as a conductivity or specific conductivity. Figure 4-1 shows the close correlation between the average total dissolved solids concentration and specific conductivity at the water quality stations in the study area.

The total dissolved solids concentration or specific conductivity may not adequately reflect the impacts of salinity on the user. For example, the domestic user is concerned about the cost of removing hardness ions, which are calcium and magnesium principally. He is also concerned about sulfate concentrations from a health standpoint. Finally, he is concerned about sodium if he is on a low-sodium diet. The other species that are major contributors to the total salinity, such as potassium and bicarbonate (the major constituent in alkalinity), are relatively unimportant to the domestic user.

The important salinity species for the industrial user in the study area are calcium, alkalinity, and sulfate. Calcium carbonate is predicted to be the first salt to precipitate in recirculated cooling tower water in all reaches where industrial use was identified as impaired. Reduction in instream calcium or carbonate concentrations would increase the number of times water could be recycled in a cooling tower, thereby reducing water consumption and water treatment costs. The same ions are critical for low-pressure boilers. For high-pressure boilers, such as those used at the Jim Bridger Power Plant, sulfate appears to be the critical ion. Therefore, a control of total dissolved solids levels in the study area may be of little benefit to industry unless calcium, alkalinity, and sulfate are controlled in the process. The actual benefit to industry from salinity control would be most accurately measured by reduction in concentrations of these three ions, rather than in concentrations of total dissolved solids.

To consider all the salinity species important to each user would make the report overly cumbersome. Therefore, in most sections of this report, including those concerning salinity in this chapter, salinity means the total salt level, expressed as total dissolved solids or specific conductivity. The implicit assumption is that a reduction in total dissolved

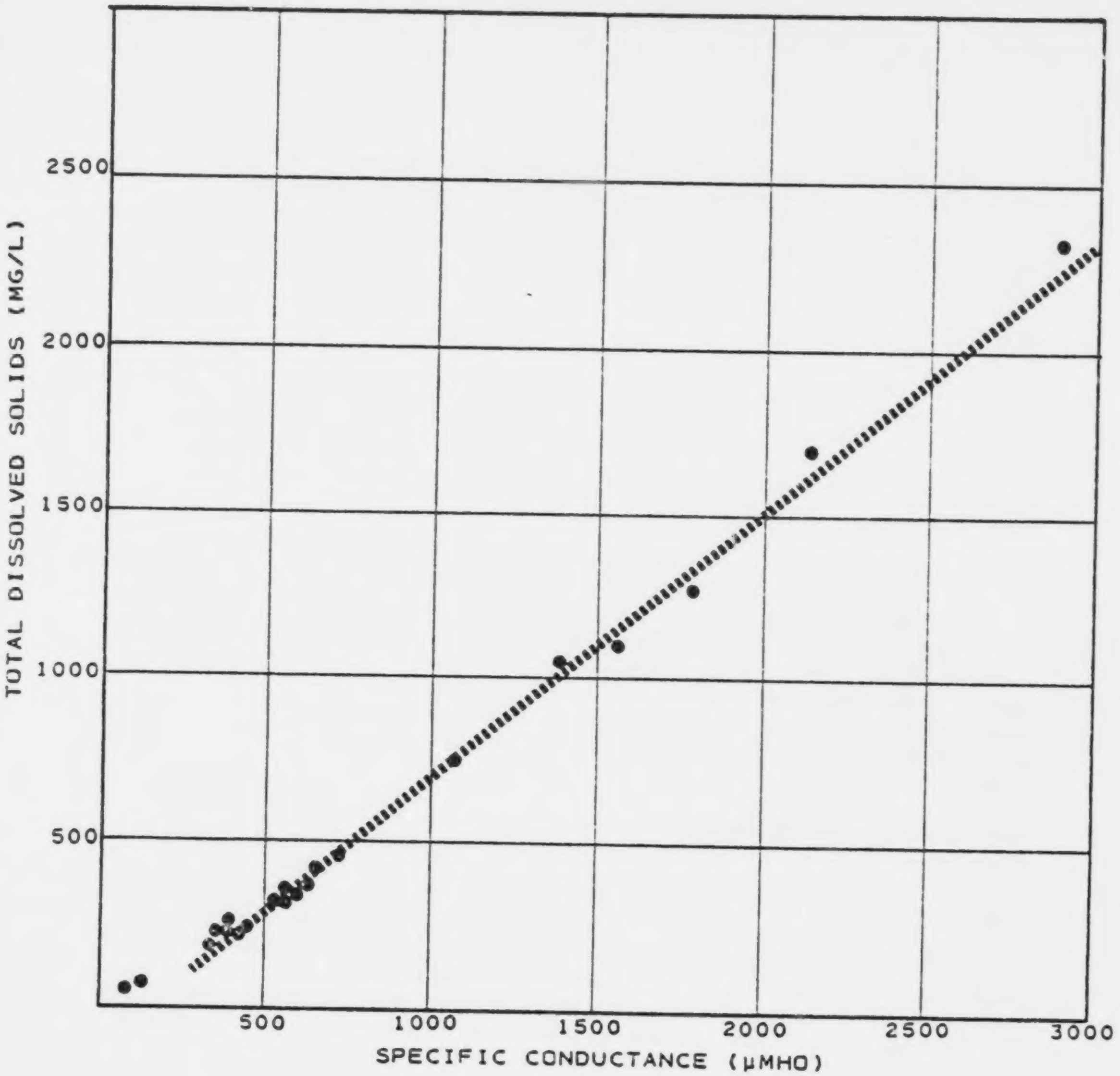


FIGURE 4-1

RELATIONSHIP BETWEEN
SPECIFIC CONDUCTANCE AND
TOTAL DISSOLVED SOLIDS
IN STUDY AREA

CH2M HILL

solids or specific conductivity will produce an equivalent reduction in the critical species, whether it is calcium, alkalinity, or sulfate. This assumption is not precisely true, however, since waters from different parts of the study area contain different proportions of salt species, as explained in Chapter 5.

COSTS OF SALINITY

The impacts associated with using water impaired by salinity can be felt by industry, agriculture, domestic water users, wildlife and livestock. As discussed in earlier chapters, some of these impacts are health-related, such as the effects of high sulfates on domestic water users, wildlife and livestock. Certainly these health-related impacts have some economic implications; for example, temporarily high sulfate concentrations will likely spur sales of anti-diarrheal products. This section addresses other salinity impacts which are not health related. These impacts are explained below and cost estimates are developed for each.

Industries in the area experience extra costs in using water with higher than recommended salt concentrations for boiler and cooling tower feed water. The salt contains chemicals that precipitate out of the water when subject to the high temperatures and pressures in boilers and cooling towers. These deposits collect in the pipes and boiler tubes and seriously diminish the efficiency of the facilities. With higher salinity levels, more treatment is required before the water can be used, or more water must be used since it can only be reused a limited number of times before the chemicals begin to precipitate.

Domestic water users have the extra costs of treating and softening saline water. Otherwise, scale forms in pipes and sinks, and more detergent is needed for washing clothes and dishes.

The agricultural cost associated with salinity is primarily the detrimental effects on crop production and soils. While agricultural costs from salinity are not a problem within the Southwestern Wyoming 208 area, they do affect agricultural users downstream due to the irrigating activity in the area.

Costs to Industry in the Study Area

Costs attributed to various levels of salinity in industrial intake water are not readily available for the area's industries. Even if the cost data were available, industries consider them proprietary information. Therefore, this study estimated the costs to industry. These estimates are based on certain generalized assumptions and at best are very general representations of conditions that could reasonably exist. However, they are adequate for planning purposes on a prefeasibility level to determine whether investigation of salinity control is warranted or not. From the cost analysis presented below, it appears feasible to investigate in more detail the specific benefits of salinity control to industry.

The major industrial water users in the study area are currently trona and power plants. In the next 20 years, the major industrial water users are expected to continue to be those involved in mineral resources development (trona, oil shale, coal gasification) and electrical power generation.

Two large power plants are located in the study area. The larger of the two is Jim Bridger, located in central Sweetwater County. This plant diverts water from the Green River above the Town of Green River. Salinity controls above this intake point appear possible. On the other hand, no salinity controls appear possible above the intake point for the other plant, Viva Naughton, located on Viva Naughton Reservoir. Therefore, only Jim Bridger is considered in this cost analysis.

The assumptions needed to calculate costs for water treatment in the mineral resources development industries are as follows:

1. Industry will use water in the amounts described in Chapter 6 based on the development scenarios. These scenarios have been reviewed by state and local agencies and industrial groups and are felt to reasonably represent future water conditions.

2. Approximately 10 percent of the water diverted by industry will be used for boiler makeup and 10 percent for cooling tower makeup. This estimate correlates well with information available from a couple of industries in the area and also agrees with figures given in the Environmental Impact Statement for oil shale development.

3. For purposes of making estimates, all boilers are assumed to operate at 600 psig and 700 degrees F.

4. Lime softening will be the only pretreatment of boiler feed water.

5. Discharge to cooling towers is assumed.

6. Blowdown rates will be approximately 12 percent when salinity is at 400 μmhos, 18 percent at 600 μmhos, and 25 percent at 800 μmhos. These values are experienced by at least one industry in the area.

7. Energy costs are assumed to be \$1.50 per 1,000,000 Btu's regardless of the energy source. No specific energy source is assumed.

8. Boilers will operate essentially full time.

9. The depletions shown in the scenarios are assumed to be for salinity levels of about 600 $\mu mho/cm^2$, which roughly approximate the salinity levels experienced in the Big Island and Green River reaches of the Green River during 1976.

10. Hardness is assumed to increase about in proportion to salinity levels. This assumption is not valid for salinity contributed from the Big Sandy Basin. However, it is valid for salinity

contributed from outside Sweetwater County in the Green River Basin. For estimating purposes, hardness is assumed to be 50, 80, and 110 mg/l as $CaCO_3$ when salinity is 400, 600, and 800 µmhos, respectively.

Based on those assumptions, costs for heating additional boiler makeup water were calculated for three different levels of development in the area--the present conditions and the conditions represented by the two scenarios described in Chapter 6. Table 4-1 shows the costs of treating for salinity that might be experienced at the Jim Bridger plant at different salinity levels. Costs were calculated to reflect conditions if salinity were to remain at 1976 levels at the intake point (600 µmhos), if salinity were to drop to summer 1977 levels found in the Slate Creek reach of the Green River above the Big Sandy River (400 µmhos), and if salinity were to remain at levels experienced during the summer of 1977 in the Big Island reach below Big Sandy River (800 µmhos).

The estimates on the table are based on known costs for water at 600 µmhos and at 800 µmhos and for an annual depletion of 30,000 acre-feet. The values for the other salinity and depletion levels are computed proportionate to the known values. The costs shown on this table include those for demineralization of the boiler makeup and for softening of cooling tower makeup water. The costs do not include those for energy needed to heat the boiler water; those energy costs are not a function of water quality because the quality (and therefore quantity) of the demineralized water heated for the boilers is independent of the raw water quality.

The total annual costs to the mineral resources development industries have also been estimated for the above three salinity levels. These costs are presented on Table 4-2. A more detailed presentation of costs to these industries is included as Appendix B. The costs on Table 4-2 include not only those for treating boiler and cooling tower makeup water, but also those for energy needed to heat boiler makeup water.

The costs to the power plant and the mineral resources development industries were combined to consider the difference in cost to industry at salinity levels higher and lower than the 1976 level of 600 µmhos. The results, given on Table 4-3, show the potential cost increase if salinity were to stay at the 1977 summer levels of the Big Island reach (800 µmhos) and the potential costs savings if salinity in the downstream reaches of the Green River was reduced to the 1977 level of the Slate Creek reach above Big Sandy River (400 µmhos). The information contained on Table 4-3 is shown graphically on Figure 4-2. This figure shows the changes in costs with changes in salinity. For reference, Figure 4-2 also shows the approximate range of salinity levels experienced in the Green River above and below the Big Sandy during 1976.

From these estimates, it can be concluded that considerable operating costs savings could be achieved if 1976 levels of salinity were maintained and that further cost savings could accrue to industries in the area if salinity could be reduced below 1976 levels. It must be remembered that the estimates described in this chapter are very rough estimates that do not apply to any specific company but generally apply to industry as a whole.

Table 4-1

COSTS FOR TREATING BOILER AND COOLING TOWER
MAKEUP WATER AT JIM BRIDGER POWER PLANT
(1977 Dollars)

Scenario	Water Diverted (ac-ft/yr)	Annual Treatment Cost[1] ($ x 10^6) 400 μ mhos Salinity	600 μ mhos Salinity	800 μ mhos Salinity
Present Day	30,000	$0.153	$0.230	$0.307
Year 2000, Coal Export	30,000	0.153	0.230	0.307
Year 2000, Energy Export	60,000	0.306	0.460	0.614

---

(1) These costs do not include energy costs for heating boiler makeup water, as explained in the text.

Table 4-2

SALINITY COSTS TO THE MINERAL RESOURCES DEVELOPMENT INDUSTRIES
(1977 Dollars)

Scenario	Annual Treatment Cost(1) ($ x 10^6) 400 μ mhos Salinity	600 μ mhos Salinity	800 μ mhos Salinity
Present Day	$1.49	$ 2.74	$ 4.59
Year 2000, Coal Export	5.19	9.12	15.3
Year 2000, Energy Export	8.91	16.4	27.5

---

(1) These costs include energy costs for heating boiler makeup water.

Table 4-3

POTENTIAL COST DIFFERENCES TO INDUSTRY AT SALINITY LEVELS HIGHER AND LOWER THAN 1976 LEVEL OF 600 μ mhos

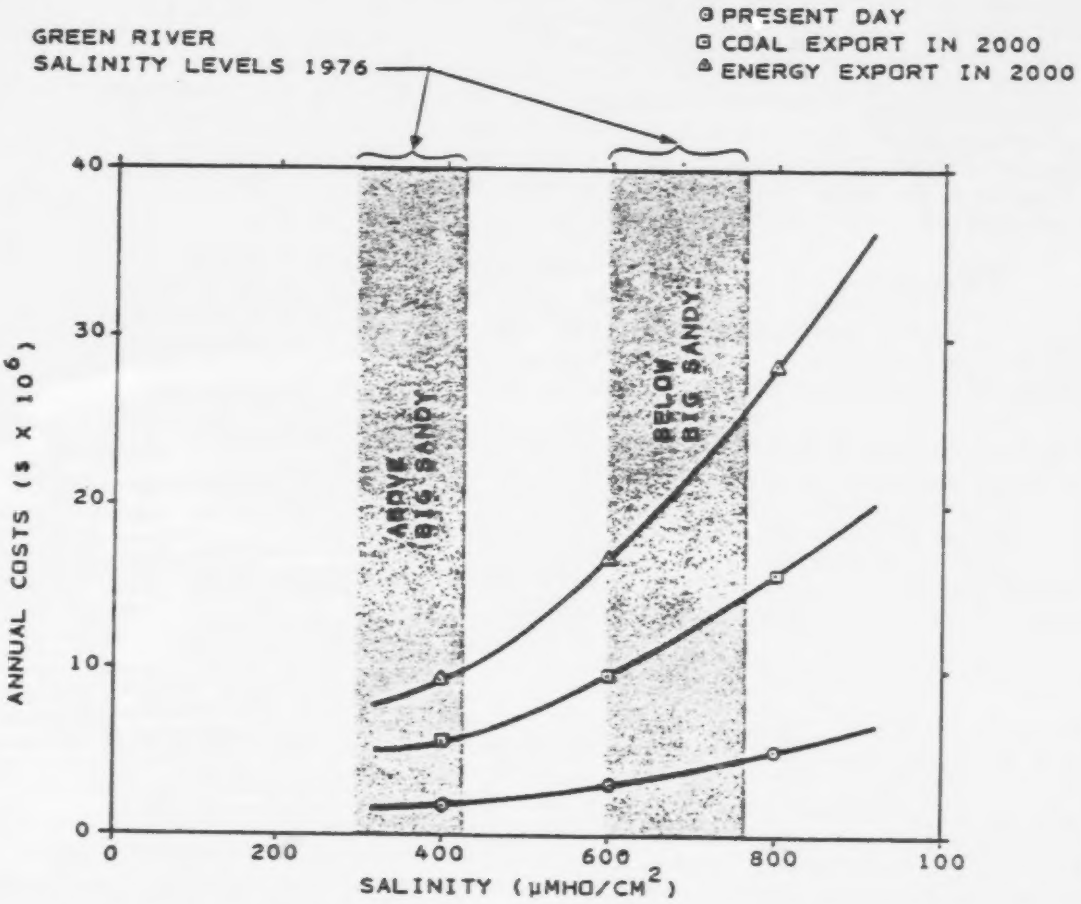
(1977 Dollars)

Scenario	Potential Annual Cost Increase At 800 μ mhos ($ x 10^6)	Potential Annual Cost Savings At 400 μ mhos ($ x 10^6)
Present Day	$ 1.93	$ 1.33
Year 2000, Coal Export	6.25	4.01
Year 2000, Energy Export	11.30	7.58

---

(1) Salinity level in Big Island reach in summer 1977 (below Big Sandy River).

(2) Salinity level in Slate Creek reach in summer 1977 (above Big Sandy River).



(NOTE: COSTS ARE FOR TREATING BOILER AND COOLING TOWER MAKEUP WATER FOR POWER PLANTS AND COSTS FOR HEATING BOILER MAKEUP WATER AND TREATING BOILER AND COOLING MAKEUP WATER FOR OTHER INDUSTRIES.)

FIGURE 4-2

SALINITY COSTS TO GREEN RIVER
BASIN INDUSTRY-1977 DOLLARS

Costs to Domestic Users in the Study Area

Estimates were made in this study of the costs of water softening to domestic water users in the study area. The cost equations used in this report are those developed by EPA for estimating salinity control feasibility for the Colorado River Basin. The cost factors have been adjusted to reflect inflation since the time of the EPA study. For this 208 study, only estimates for surface water users are included even though it is recognized that a considerable number of ground water users may also have softeners or be subjected to increased soap costs due to high hardness. The data on ground water users were not readily available.

Costs related to salinity have been estimated for three types of public water supply users in the area--those on central softening, those on individual softeners, and those without softeners. The number of surface water users in each of these three categories is shown on Table 4-4 according to various communities in the study area.

The costs to these domestic users for various salinity levels and for various levels of development in the study area are presented on Table 4-5. Costs are due to two factors, either increased consumption of softener and regenerant or increased soap consumption. Table 4-5 shows that the total costs in the area are likely to rise simply because of increased population in the future. However, costs are also shown to be greater if salinity levels increase over the 1976 levels.

Benefits and Costs in the Study Area

From the foregoing analyses, it seems that at least $2 million per year would be saved by industrial and domestic water users in the study area if salinity returned to 1976 levels from their 1977 levels and that further savings would accrue for lower levels yet. There is obviously considerable economic benefit to be gained by lower salinity levels. However, these benefits (or cost savings) must be compared with the costs to reduce the salinity and maintain lower levels. The costs for various salinity controls are presented in Chapter 8. Also, a cost-benefit analysis is given in that chapter.

Costs of Salinity To Users Outside Study Area

The Colorado River Salinity Control Forum has estimated the annual municipal, industrial, and agricultural benefits to be gained by reducing salinity at Imperial Dam, California, on the Lower Colorado River. These benefits pertain only to users of water from the Lower Colorado River Basin. The benefits in dollars per part per million (ppm) reduction in salinity at Imperial Dam are estimated at $430,000. (1) This benefit is equivalent to

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(1) Wyoming State Engineer and U.S. Department of Agriculture. April 1978. Cooperative River Basin Study, Green River Basin, Wyoming.

Table 4-4

NUMBER OF SURFACE WATER USERS IN STUDY AREA WITH AND WITHOUT SOFTENING

Community	Users with Individual Softening			Users with No Softening		
	Present Day(1)	Year 2000 Coal Export(2)	Year 2000 Energy Export(2)	Present Day(1)	Year 2000 Coal Export(2)	Year 2000 Energy Export(2)
Evanston	1,000	2,850	1,930	4,000	11,370	7,710
Green River	10,000	12,000	25,000	3,000	4,000	8,000
Jamestown/Rio Vista	750	800	1,900	250	300	600
Rock Springs	18,000	22,000	46,000	6,000	7,000	15,000
Granger, Little America	40	264	--(3)	160	1,056	--(4)
Diamondville, Frontier, and Kemmerer	720	2,100	11,630	2,880	8,798	6,510

---

(1) Estimates from Culligan Water Conditioning Company, Denver, Colorado.
(2) Estimates based on projected populations.
(3) No data available.

Table 4-5

ESTIMATED ANNUAL SOFTENING COSTS TO DOMESTIC USERS
(1977 Dollars)

Community	Present Day			Year 2000, Coal Export			Year 2000, Energy Export		
	1976 Salinity Levels	Salinity 50% Greater Than In 1976	Salinity 50% Less Than In 1976	1976 Salinity Levels	Salinity 50% Greater Than In 1976	Salinity 50% Less Than In 1976	1976 Salinity Levels	Salinity 50% Greater Than In 1976	Salinity 50% Less Than In 1976
Evanston	$56,300	$ 58,440	$54,300	$160,000	$166,200	$154,300	$108,500	$112,650	$104,700
Green River Jamestown/Rio Vista Rock Springs	93,840	156,998	30,518	163,370	244,950	81,600	245,050	367,400	122,400
Granger, Little America	2,281	2,377	2,185	15,060	15,700	14,422	-- (1)	-- (1)	-- (1)
Diamondville, Frontier, and Kemmerer	42,800	45,400	40,200	130,250	137,950	122,560	113,120	119,350	106,800

---

(1) No data available.

$31 per ton of salt reduction in the Colorado River system. Therefore, it is assumed that $31 of benefits will be gained outside the study area for each ton of salt reduction within the study area.

COSTS OF EUTROPHICATION TO RECREATION

Eutrophication cannot only lessen the aesthetic value of a water body, but can also result in an economic loss to the tourist industry as recreational uses are impaired. Excessive algal and weed growth can decrease recreational use of a reservoir in a number of ways. Sightseers and swimmers are discouraged by the unsightliness of the algal mats and their rank odors. Boaters are frustrated by the clogging of propellers. Fishermen leave because rough fish, such as carp, have taken over the waters. Those services which depend on recreationalists therefore suffer severe economic setbacks when the recreational opportunities in the reservoir are lost.

It is impossible to predict at what rate eutrophication is spreading in the reservoirs or when it might eliminate recreational opportunities such as fishing, boating, and swimming. None of the reservoirs has become so eutrophic that recreational opportunities have been lost. However, all reservoirs have shown some signs of eutrophication, including excessive growths of blue-green algae, low oxygen levels, and high phosphorus concentrations.

Costs to the Study Area

The largest recreational use of any reservoir in the study area in terms of numbers of visitors occurs at Flaming Gorge Reservoir. Recreationalists have complained about algal blooms in the Green River and Blacks Fork arms of the reservoir, which have become increasingly severe over the last decade. However, despite the complaints, these water quality problems have not appeared to deter recreational use of the reservoir. As shown on Figure 4-3, recreational use has actually increased, while the water quality has deteriorated in the reservoir. The growth rate of recreational use of the reservoir has been compared to the growth rate of Salt Lake City, the nearest metropolitan center, over the 1970-1976 period. (More visitors come to Flaming Gorge from Salt Lake City than any other single area.) The growth rate of recreational use actually exceeded the growth rate of Salt Lake City over the period. The seeming disparity between decreased quality and increased use may be explained by the fact that the decreased quality is not yet felt throughout the reservoir. Quality degradation has started in the Green River and Blacks Fork arms at the upper end of the reservoir and is slowly progressing down the reservoir. The lower end still has good quality.

Recreational use of the reservoir is dependent essentially on how good the fishing is. In an analysis of the *Economic Impact on Southwestern Wyoming of Recreationists Visiting Flaming Gorge Reservoir*, it was found that 99 percent of the visitors to the reservoir came to fish. Although water quality has deteriorated aesthetically from the extensive algal blooms, record-size game fish have been caught in the reservoir in the last 2 years. The mean weight per trout harvested by the Utah State Division of Fish and

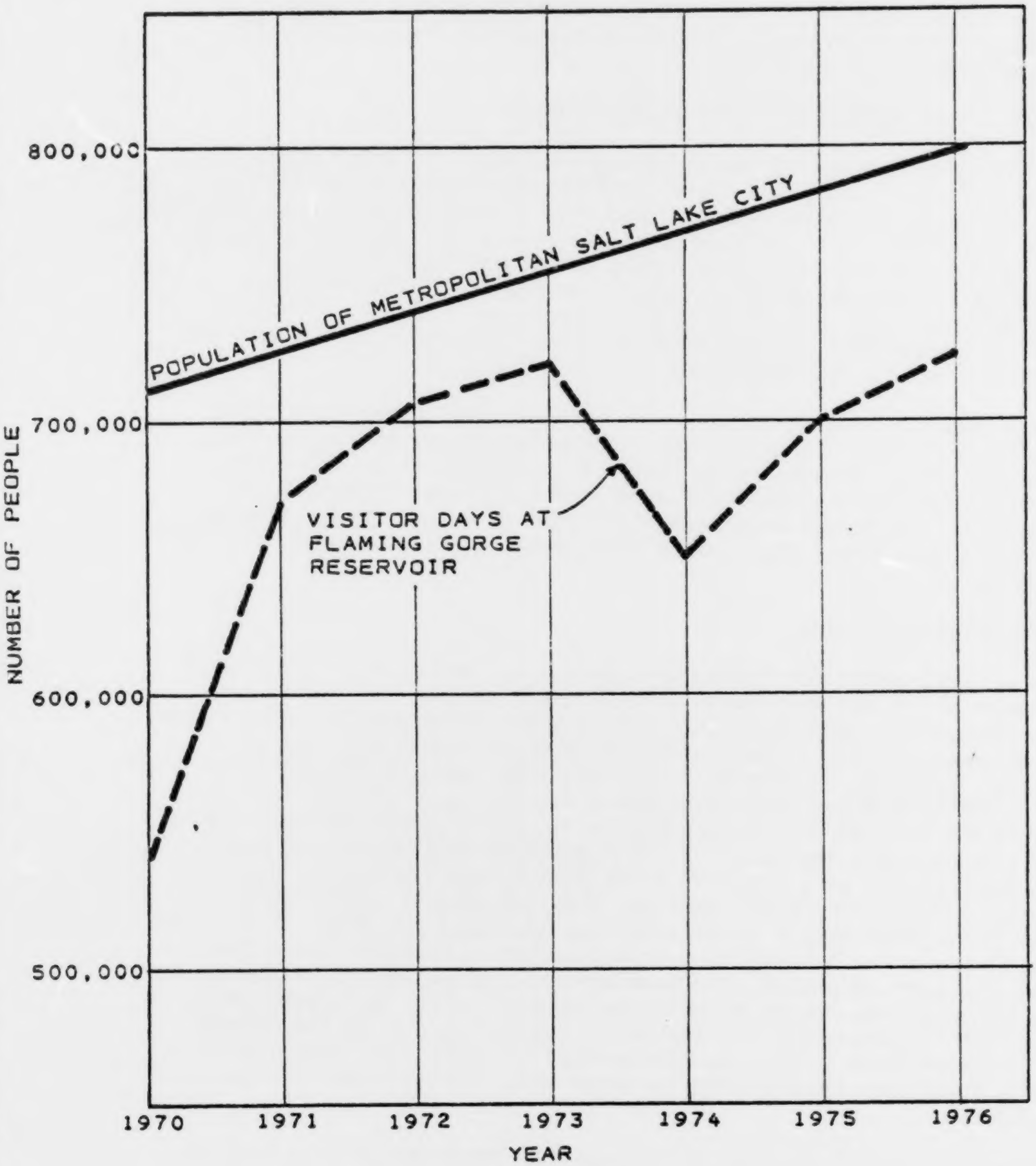

FIGURE 4-3

RECREATIONAL USE OF FLAMING GORGE RESERVOIR

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Game and by the Wyoming Game and Fish Department doubled from 1964 to 1969 (*Green River and Flaming Gorge Post-Impoundment Investigations*). This increase in fish size is common in a reservoir during the incipient stages of eutrophication because of the abundance of food.

Also common in a reservoir or lake in the incipient stages of eutrophication is a decrease in the number of game fish and an increase in the number of nongame fish. Figure 4-4 shows that the trout population decreased from 84 percent of the total fish population in 1964 to 9 percent of the population in 1969. The harvest rate of trout has also decreased from 1.23 fish per gill-net hour in 1964 to 0.35 fish per gill-net hour in 1975. During the same period the Utah chub population increased from 1 percent of the total fish population to 76 percent.

Although the trend described above is striking, two other factors besides eutrophication may explain some or all of the changes observed in the reservoir. First, Wyoming Game and Fish Department personnel have noted such a trend in other new reservoirs; they ascribe the changes to the radical alteration of habitat from a free-flowing stream to a still-water impoundment. Second, gill nets are more selective for Utah chub, and therefore the changes may not be as striking as the data indicate. Because of these other two factors, it cannot be stated conclusively that (1) the population changes are as radical as the data indicate or (2) eutrophication is the sole cause of the changes. However, whether or not the recent changes are due to eutrophication, the literature provides ample documentation that eutrophication can eventually bring about such changes. As shown in the next chapter, present phosphorus loadings to the reservoir appear capable of promoting further eutrophication and eventual loss of game fish in the reservoir.

Fishing is an important economic asset to Southwestern Wyoming. Benefits to the study area from recreational use of the reservoir were estimated to exceed $1 million in 1965.(1) When inflated to the present, these annual benefits exceed $2 million. Benefits to each service sector are presented on Table 4-6.

Because fishing is the recreational activity inducing these benefits, most of them will be lost if the fishing opportunities are lost in the reservoir. As noted earlier, it is impossible to predict at what rate recreational opportunities will be lost if present phosphorus loadings to the reservoir are allowed to continue or increase. However, based on present benefits, eutrophication of Flaming Gorge Reservoir may cause approximately a $2 million annual loss in revenue to the study area.

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(1) Benefit data came from *Economic Impact on Southwestern Wyoming of Recreationists Visiting Flaming Gorge Reservoir*.

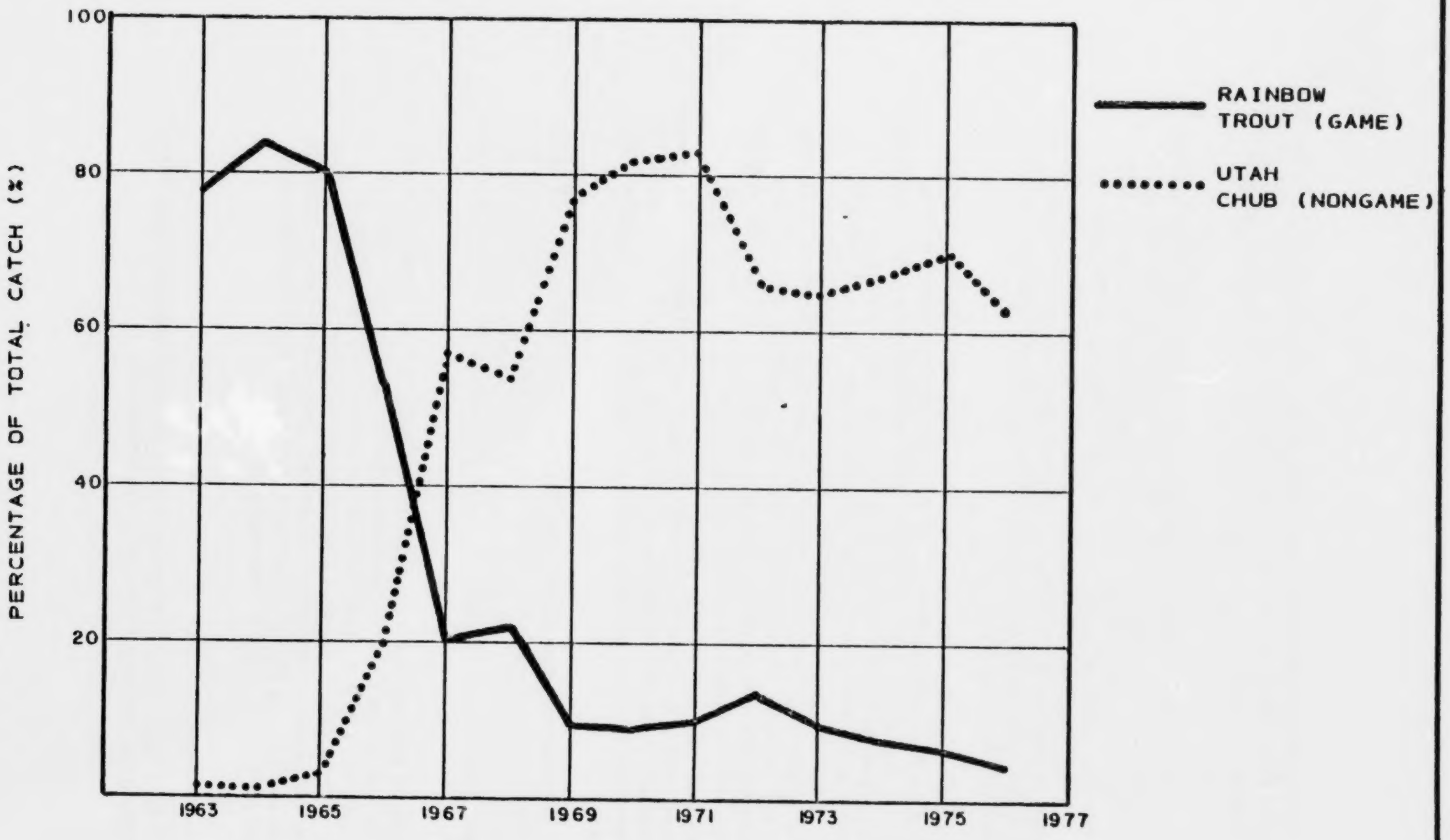

FIGURE 4-4

CHANGE IN FISH POPULATIONS IN FLAMING GORGE RESERVOIR

REFERENCE: GREEN RIVER AND FLAMING GORGE POST-IMPOUNDMENT INVESTIGATIONS

Table 4-6

ANNUAL BENEFITS TO SOUTHWESTERN WYOMING FROM RECREATIONISTS VISITING FLAMING GORGE RESERVOIR

Sector	Direct Benefit	Indirect Benefit (1)	Total Benefit
Gasoline service stations	$ 527,000	$ 10,000	$ 537,000
Other retail	275,000	161,000	436,000
General wholesale	0	343,000	343,000
Households	0	335,000	335,000
Food and beverage establishments	269,000	18,000	287,000
All other sectors	0	274,000	274,000
TOTAL	$1,071,000	$1,141,000	$2,212,000

---

(1) Indirect benefits are those induced by the direct benefits. For example, a retailer invests income earned through sales to recreationalists in a house; the purchase of that house is an indirect or induced benefit to the economy.

Costs Outside the Study Area

The total contribution of Flaming Gorge Recreation Area to the national economy has been estimated from information provided by the Wyoming Game and Fish Department on fisherman days for the entire reservoir during 1976 and on the value of a fisherman day. The estimated contribution is $8.8 million per year. The estimated annual economic value of the reservoir to those outside the study area is:

Total annual benefit:	$8.8 million
Benefits to study area:	2.2 million
Benefit outside study area:	$6.6 million

As was done for costs within the study area, it has been assumed that these benefits will eventually be lost to eutrophication if present conditions are allowed to persist.

Chapter 5
CONTAMINANT SOURCES

The overall direction of this technical report is (1) the identification of water quality problems and problem contaminants, (2) the identification of the sources of those contaminants, and (3) the development of management plans to control those sources. The first step was completed in Chapter 3. Locations of impaired uses and the contaminants causing those impairments are summarized on Table 3-8.

The second step, which is the identification of the contaminant sources, is taken in this chapter. The contaminants and contaminant sources that will be addressed in this chapter are listed on Table 5-1. These sources have been separated into point and nonpoint, as defined in Chapter 1. At the end of this chapter, an evaluation is made about the relative importance of each contaminant source to the total loading of a particular contaminant.

LOADS IN SURFACE WATERS

This chapter begins with calculations of total instream loads of certain contaminants. These calculations have been made for two reasons: (1) to determine what geographical areas are the major contributors of contaminants and (2) to ascertain the relative importance of each contaminant source to the total load carried by the streams.

Instream surface water loads have been estimated for phosphorus and four salinity species, including alkalinity, calcium, sulfate, and total dissolved solids. In addition, total suspended solids loads were estimated in order to determine areas of high erosion. Fecal coliform and dissolved oxygen loads were not calculated because of lack of information.

The conclusion has been reached in the previous two chapters that the major problems related to phosphorus and salinity occur in the Green River Basin. Therefore, instream loads of phosphorus, salinity, and total suspended solids have been calculated only for that basin.

Suspended Solids in Surface Waters

Annual suspended solids loads have been determined by the U.S. Geological Survey at the stations designated Green River near Green River and Blacks Fork near Little America. These two stations are located just above Flaming Gorge Reservoir, as shown on Figure 5-1. Annual loads are presented on Figure 5-2. On the average, the Blacks Fork carries more than twice as much sediment to the reservoir as the Green River. Annual loads vary widely on both rivers.

Table 5-1

POTENTIAL CONTAMINANT SOURCES

Contaminant Source	Possible Influence in Study Area				
	Salinity	Phosphorus	Fecal Coliform	Dissolved Oxygen	Radioactivity
Point Sources					
Mining and Industrial Discharges	X				
Municipal and Private Treated Sewage Discharges		X	X	X	
Dairies and Feedlots		X	X	X	
Stack Emissions	X				
Springs	X				
Nondischarging Wastewater Ponds	X				
Nonpoint Sources					
Geologic Erosion	X	X		X	X
Overgrazing	X	X			
Mining Site Erosion		X			
Construction Site Erosion		X			
Agricultural Runoff		X			
Manure Runoff		X	X	X	
Urban Runoff		X			
Septic Tanks		X	X	X	
Irrigation Return Flows	X				
Natural Ground Water Discharges	X				
Silviculture		X			
Residual Wastes Management		X		X	
Oil Spills				X	

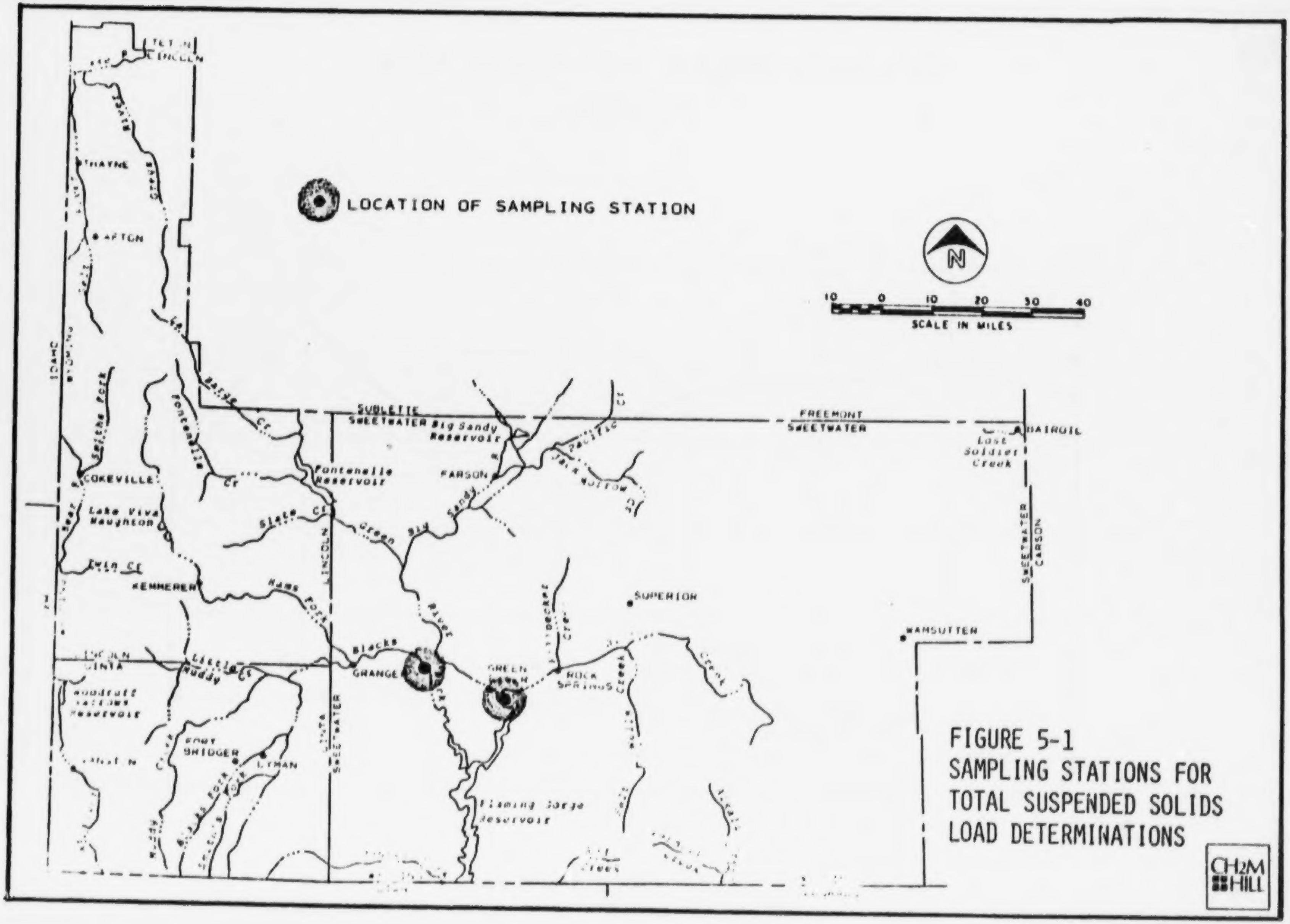
LOCATION OF SAMPLING STATION
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
THAYNE
AFTON
IDAHO
WYOMING
COKEVILLE
Lake Viva Naughton
Twin Cr
KEMMERER
Fontenelle
Cr
Fontenelle Reservoir
Slate Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Big Sandy
Green
River
Hams Fork
LINCOLN
UINTA
SWEETWATER
Blacks Fork
GRANGE
GREEN RIVER
ROCK SPRINGS
Little Muddy Cr
Muddy
Woodruff Narrows Reservoir
FORT BRIDGER
LYMAN
Flaming Gorge Reservoir
Pacific
Jack Morrow
Cr
SUPERIOR
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
Creek

FIGURE 5-1
SAMPLING STATIONS FOR
TOTAL SUSPENDED SOLIDS
LOAD DETERMINATIONS

CH2M HILL

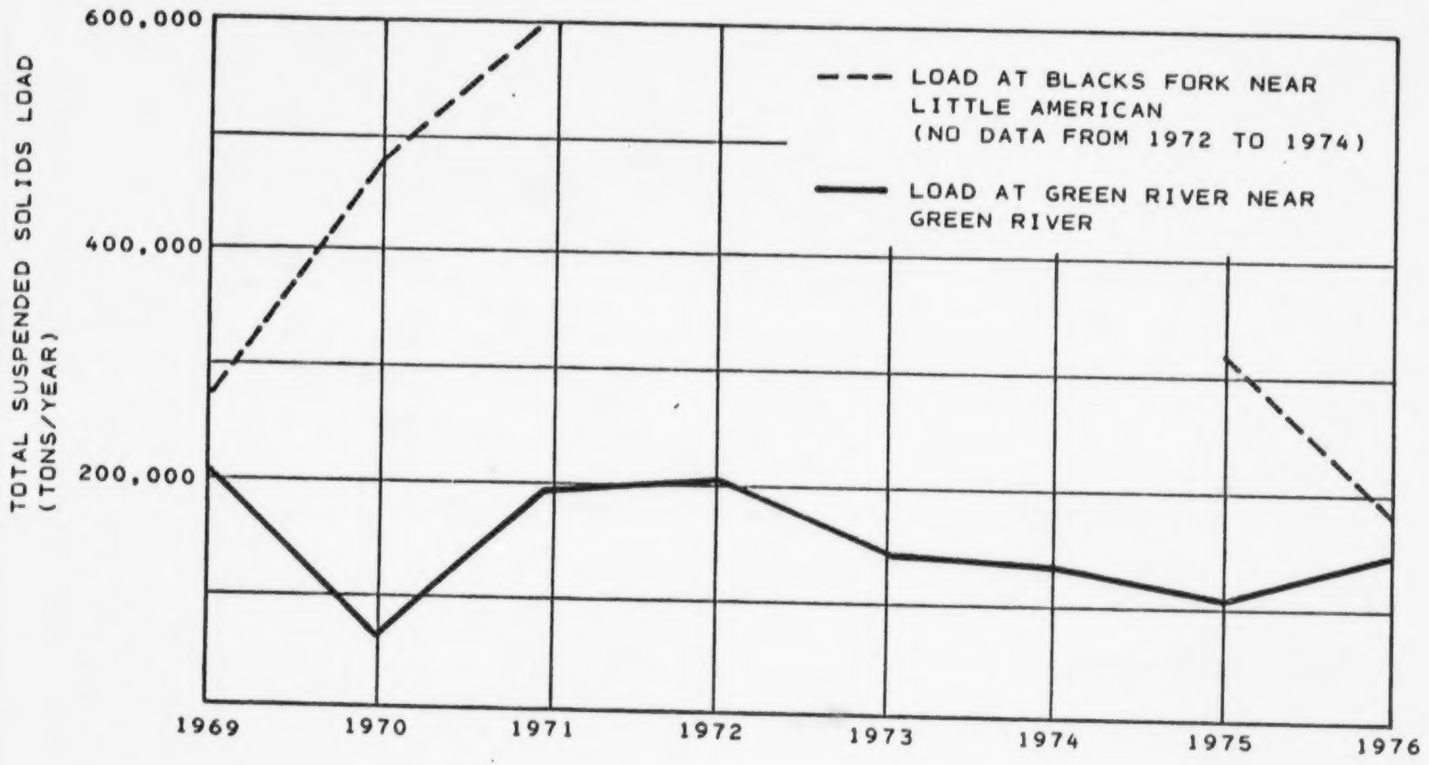

FIGURE 5-2

ANNUAL INSTREAM TOTAL SUSPENDED SOLIDS LOADS

Phosphorus Loads in Surface Waters

Phosphorus was monitored on a monthly basis in 1975 and 1976 at several stations in the Green River. Annual phosphorus loads were estimated by calculating an instantaneous loading rate (flow times concentration) for each monthly sample, assuming this loading rate to be representative of the entire month, calculating a monthly load from that rate, and summing the loads for 12 months.

This method for calculating annual loads gave erroneous values for the smaller tributaries, where flow and phosphorus concentrations were found to change by several orders of magnitude within a period of a few hours. A single monthly sample from these small streams is unlikely to provide results characteristic of a particular runoff event, much less an entire month. However, in the larger tributaries and rivers, where flows and phosphorus concentrations were more consistent over a 30-day period, the method gave apparently reasonable values. Therefore, estimates of annual instream loads for only the main rivers and large tributaries are discussed here.

Estimated annual phosphorus loads in the Green River Basin are shown on Figure 5-3 for three stations in the Green River watershed (A, B, C) and one in the Blacks Fork watershed (D). Phosphorus loads in the Green River were estimated to increase by six times in 1975 and by 13 times in 1976 as it flowed from Fontenelle Reservoir (Station A) to Flaming Gorge Reservoir (Station C). Most of the increase in both years appeared to come from the Bitter Creek drainage. The phosphorus load carried by the Green River to Flaming Gorge Reservoir varied considerably from 1975 to 1976. For example, the phosphorus load in the Green River below Bitter Creek (Station C) in 1975 was only 38 percent of the load at the same station in 1976. The variation appears to be caused by changes in the erosion rates; this phenomenon is covered in detail in a later section of this chapter on geologic erosion.

The 1976 phosphorus load at the mouth of the Blacks Fork is also shown on Figure 5-3. The phosphorus load at the mouth of the Blacks Fork was generated from data on the three major tributaries, Smiths Fork, Muddy Creek, and Hams Fork. It was assumed that the average unit load from the three Blacks Fork tributaries of 50 pounds per square mile per year was representative of the entire Blacks Fork drainage. The generated load in 1976 for this station of 80 tons per year is approximately equal to the EPA estimate for the Blacks Fork, made in 1975 during the National Eutrophication Survey. In 1976, Blacks Fork was estimated to deliver only one-quarter as much phosphorus to Flaming Gorge Reservoir as the Green River.

Salinity Loads in Surface Waters

Loads of alkalinity, calcium, sulfate, and total dissolved solids were calculated for four stations on the Green River and two on the Blacks Fork by the same method used for calculating phosphorus loads. Unlike phosphorus loads, calculated loads for all four salinity parameters differed little from 1975 to 1976. Therefore, the following discussion is based on the averages of the 2 years.

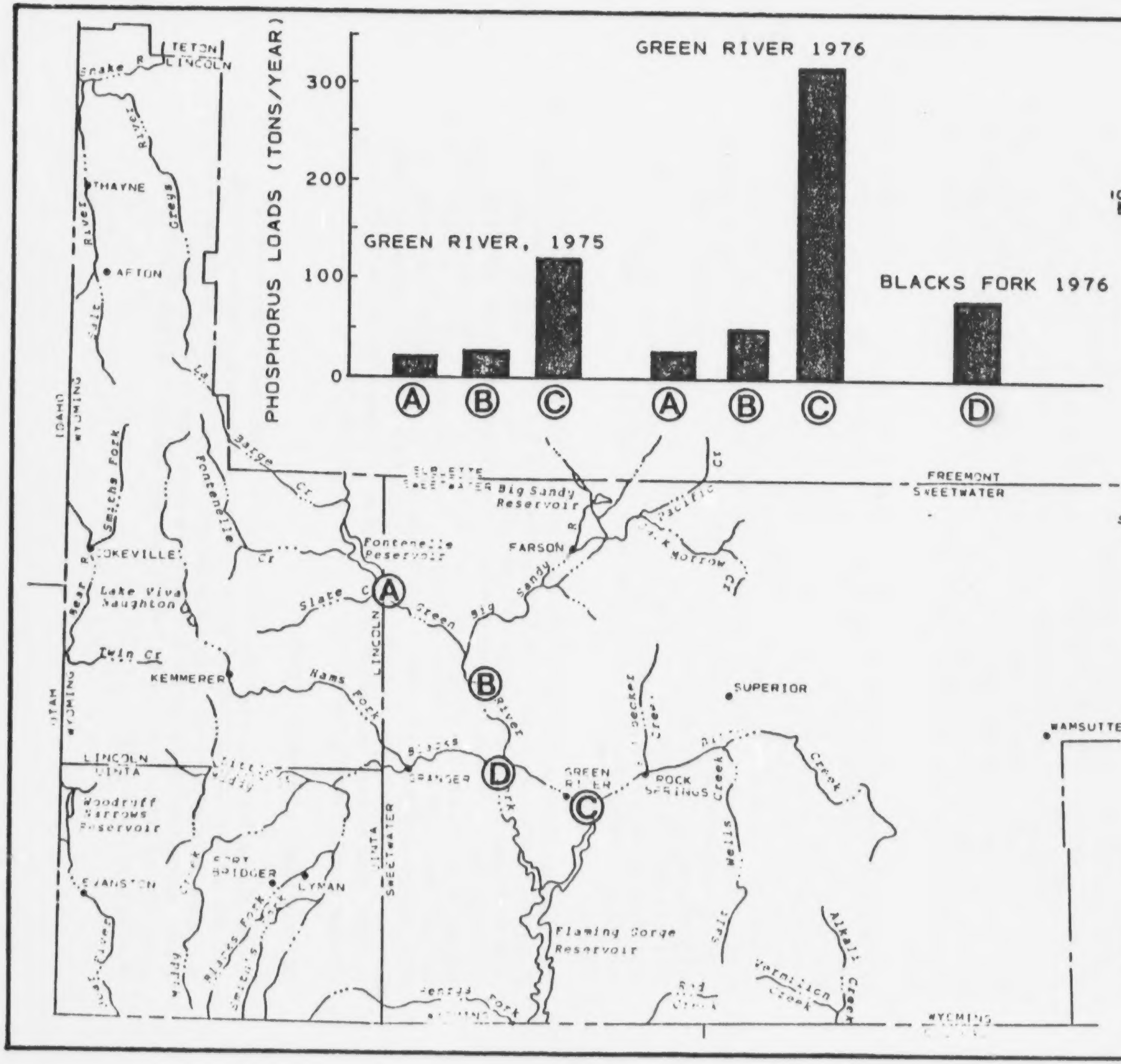
PHOSPHORUS LOADS (TONS/YEAR)
300
200
100
0
GREEN RIVER, 1975
GREEN RIVER 1976
BLACKS FORK 1976
Ⓐ
Ⓑ
Ⓒ
Ⓓ
N
SCALE IN MILES
10
0
10
20
30
40
TETON
LINCOLN
Snake R
THAYNE
AFTON
Greys
River
Salt
Smiths Fork
IDAHO
WYOMING
OKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMERER
UTAH
WYOMING
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
FORT BRIDGER
LYMAN
Blacks Fork
Smith's Fork
La Barge Cr
Fontenelle Cr
Fontenelle Reservoir
Slate C
Hams Fork
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Big Sandy R
Green River
Pacific Cr
Jack Morrow Cr
LINCOLN
SWEETWATER
UINTA
SWEETWATER
GRANGER
Blacks Fork
GREEN RIVER
Flaming Gorge Reservoir
Henrys Fork
Bitter Creek
Killpecker Creek
ROCK SPRINGS
Salt Wells Creek
SUPERIOR
Vermilion Creek
Red Creek
Alkali Creek
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
WYOMING

FIGURE 5-3

ANNUAL INSTREAM PHOSPHORUS LOADS

CH2M HILL

Load estimates are shown on Figure 5-4 for four areas on the Green River. Area 1 identifies the approximate salt load in the Green River as it enters the study area. Total dissolved solids loads increase by 143 percent from 300,000 tons per year to 730,000 tons per year as the Green River passes through the study area. Much of the increase occurs in the area encompassing the Big Sandy River drainage. The water is characteristically calcium bicarbonate as it enters the study area. However, within the study area, most of the salinity increase is due to loadings of sodium and sulfate. Sulfate loads in the Green River increase almost five times during its course through the study area.

The U.S. Geological Survey has estimated salinity loads on the Green River over the 1970-1975 period through the use of a multiple-variable regression model (DeLong, 1977). The total dissolved solids load estimates shown on Figure 5-4 differ by less than 15 percent from the U.S.G.S. estimates. The U.S.G.S. has roughly estimated that approximately 50 percent of the total salinity load generated in Area 3 comes from seeps in the final 30 miles of the Big Sandy River, approximately 43 percent comes from the rest of the Big Sandy River drainage, and only 7 percent comes from all the remaining region covered by Area 3. These numbers may change as more water quality data are collected. However, any new numbers will probably continue to show the Big Sandy River is a major salt contributor to the Green River system.

Salt loads in two stretches in the Blacks Fork are shown on Figure 5-5. Three-quarters of the salt load delivered by the Blacks Fork comes from above the confluence with the Smiths Fork. The lower Blacks Fork, Muddy Creek, and Hams Fork account for the remaining one-quarter of the load. The salts in both stretches are predominantly sodium sulfate.

In summary, salt load increases within the study area from the Blacks Fork and Green River drainages averaged approximately 760,000 tons per year in 1975 and 1976. About 40 percent of this increase came from the Blacks Fork. The increased salt load in both drainages is primarily due to increases in sodium and sulfate.

Henrys Fork also delivers salt from the study area to the Colorado River. Salt loads from Henrys Fork averaged 110,000 tons per year in 1975 and 1976. The salts were primarily calcium sulfate.

Summary of Instream Loads

Three important conclusions can be drawn from the load estimates. These are presented below:

- Certain areas appear to contribute disproportionate amounts of the phosphorus and total salinity loadings. In 1975 and 1976, much of the phosphorus delivered to Flaming Gorge Reservoir was generated in the Bitter Creek drainage while much of the salinity was generated in the Big Sandy drainage and Bridger Valley.

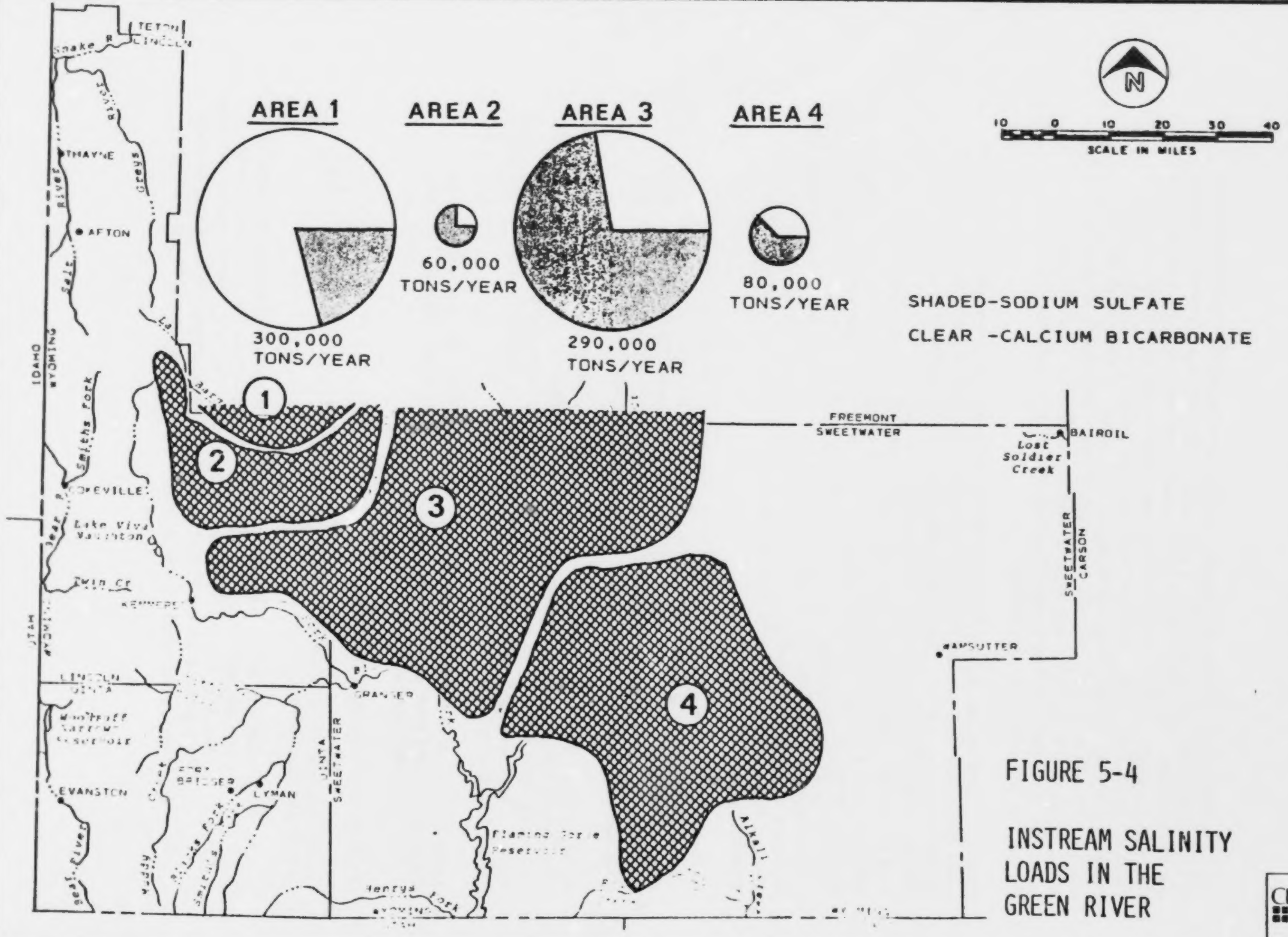
AREA 1
300,000 TONS/YEAR
AREA 2
60,000 TONS/YEAR
AREA 3
290,000 TONS/YEAR
AREA 4
80,000 TONS/YEAR
SHADED-SODIUM SULFATE
CLEAR -CALCIUM BICARBONATE
N
10 0 10 20 30 40
SCALE IN MILES
1
2
3
4
TETON
LINCOLN
Snake R
THAYNE
AFTON
Greys River
Salt River
IDAHO
WYOMING
UTAH
Smiths Fork
COKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMERER
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
Bear River
FORT BRIDGER
LYMAN
Blacks Fork
Smiths Fork
Muddy Creek
UINTA
SWEETWATER
GRANGER
Flaming Gorge Reservoir
Henrys Fork
WYOMING
UTAH
Alkali
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
CH2M HILL

FIGURE 5-4

INSTREAM SALINITY LOADS IN THE GREEN RIVER

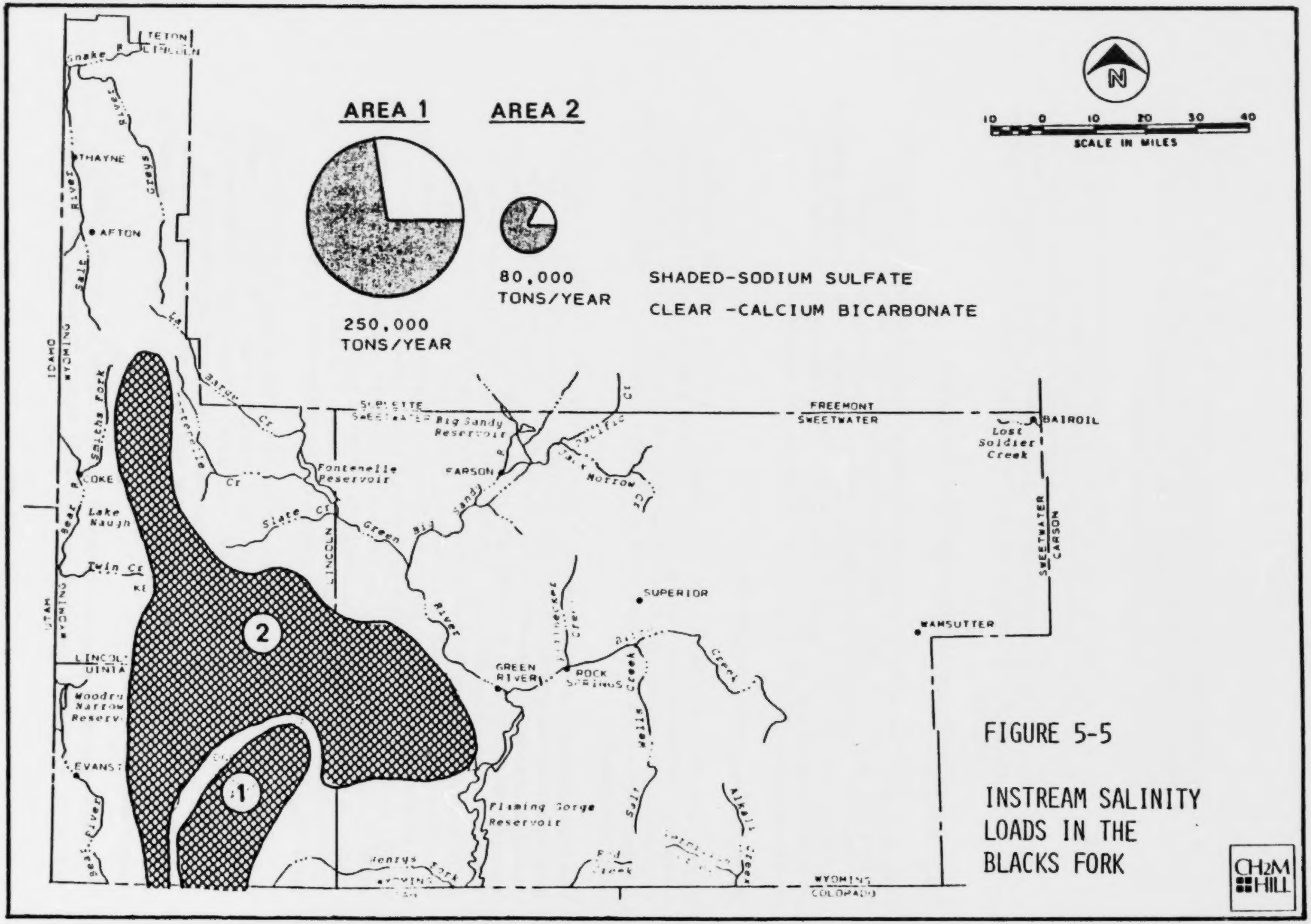
AREA 1
AREA 2
250,000 TONS/YEAR
80,000 TONS/YEAR
SHADED-SODIUM SULFATE
CLEAR -CALCIUM BICARBONATE
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Salt River
Greys River
La Barge Cr
Fontenelle Cr
Smiths Fork
COKE
Bear R
Lake Naughton
Twin Cr
IDAHO
WYOMING
UTAH
WYOMING
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
Bear River
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Slate Cr
Green River
Big Sandy
Pacific Cr
Little Sandy
Jack Morrow Cr
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
SUPERIOR
WAMSUTTER
Killpecker Creek
GREEN RIVER
ROCK SPRINGS
Bitter Creek
Salt Wells Creek
Alkali Creek
Red Creek
Flaming Gorge Reservoir
Henrys Fork
WYOMING
UTAH
WYOMING
COLORADO
2
1

FIGURE 5-5

INSTREAM SALINITY LOADS IN THE BLACKS FORK

CH2M HILL

- Phosphorus loadings increased greatly from 1975 to 1976. The large change suggests that erosion may be a more important phosphorus contributor than a relatively constant source such as municipal wastewater treatment plants.
- U.S.G.S. data for the 1970-1975 period and the data used in this study for 1975 and 1976 show that salinity loads are more consistent from year to year than phosphorus or suspended solids loads. This consistency suggests that relatively constant sources such as natural ground water discharges may be the major salinity contributors.

DESCRIPTION AND ASSESSMENT OF POINT SOURCES

This section of the report summarizes the point source discharge conditions in the study area. The point sources considered in this section are listed on Table 5-1. The evaluation of point sources is based on water quality data dated June 13, 1977, from the STORET system and on information gathered by SWWQPA during the course of this study. The locations of all discharges monitored under the NPDES program are shown on Figure 5-6.

Mining and Industrial Discharges

Mining and industries have generally gone to a total containment (nondischarging) system for their wastewater. The few dischargers are presently in compliance with the permit requirements. In the past, three discharge problems have been associated with mining and industry. These problems are described below.

The Star Valley Cheese Company at Thayne is the only industry in the study area which discharges to a municipal wastewater treatment facility. The municipal treatment process is spray irrigation of digested wastes. The type and volume of wastes discharged to the treatment plant is incompatible with the design of the facility. The influent to the plant has extremely high concentrations of BOD_5 and nutrients because of the impact of the industrial discharge on the total load. These strong wastes have created odor problems at the plant and in the Town of Thayne. Digested wastes are being applied to gravelly soils with a high water table. Soil capacity for removal of contaminants may be exceeded; however, no water quality problems related to discharges from the plant have been noted at the monitoring station downstream on the Salt River. However, Flat Creek, which is the apparent receiving waters, has sludge deposits and mats of algae.

A second discharge problem occurred in 1973 at the Union Pacific Railroad yard in Green River. Phosphorus concentrations of up to 330 ppm in runoff from the yard were recorded by EPA that year. These high concentrations were due in part to the washing of railroad cars containing phosphorus. A separate full retention facility for the car washings has been constructed, and the treated discharges from the yard are presently meeting all discharge requirements.

The third discharge problem occurs at South & Jones Lumber Company in Evanston, which was identified in the 305(B) report to be in noncompliance

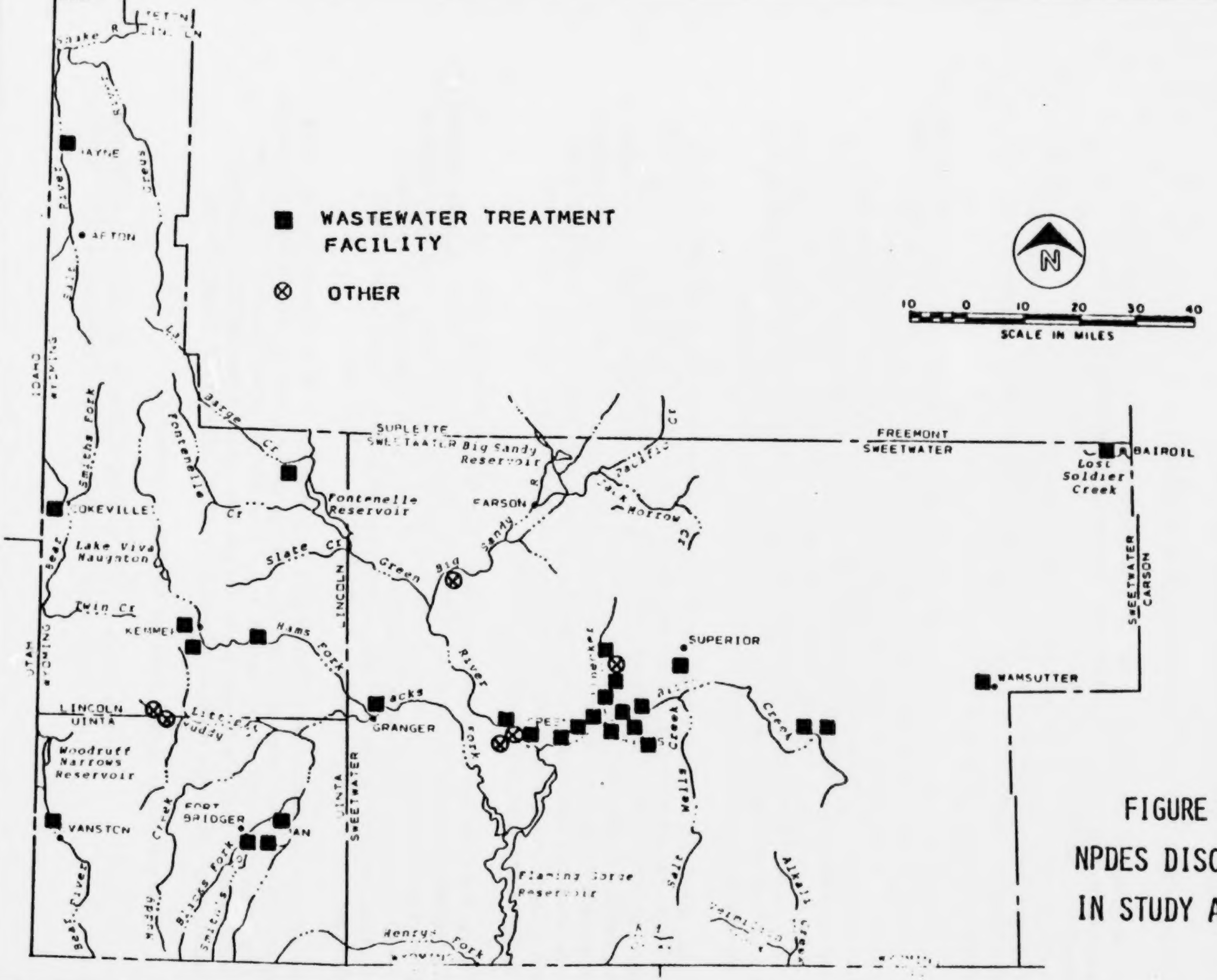
■ WASTEWATER TREATMENT FACILITY
⊗ OTHER
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
AFTON
River
Greys
Salt
IDAHO
WYOMING
Smiths Fork
Fontenelle
Barge Cr
La
Cr
COKEVILLE
Lake Viva Naughton
Bear
Twin Cr
KEMMERER
Hams Fork
UTAH
WYOMING
LINCOLN
UINTA
Little
Muddy
Woodruff Narrows Reservoir
EVANSTON
Bear River
Muddy
Creek
FORT BRIDGER
Blacks Fork
Smiths
SUBLETTE
SWEETWATER
Big Sandy Reservoir
Fontenelle Reservoir
Slate Cr
LINCOLN
UINTA
SWEETWATER
Green
Big
Sandy
FARSON
R
Pacific
Jack Morrow
Cr
Cr
River
Blacks
GRANGER
Fork
Killpecker
SUPERIOR
Bitter
Creek
Salt
Wells
Creek
Flaming Gorge Reservoir
Henrys Fork
Vermilion
Alkali Creek
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARBON
WAMSUTTER

FIGURE 5-6
NPDES DISCHARGERS
IN STUDY AREA

with best practical treatment standards in 1976. Discharge from the yard goes to the Bear River. The permit to the lumber yard has been recently issued and no discharge quality data are available. The Bear River reach below Evanston does not show any use impairments caused by contaminants which might be discharged from the lumber yard.

Municipal and Private Treated Sewage Discharges

At the outset of the 208 program in Southwestern Wyoming, effluent from most of the municipal facilities was not meeting secondary treatment standards, as defined on Table 5-2. Excessive concentrations of fecal coliform and BOD_5 in the effluent were recognized as possible water quality problems early in the study. In addition, municipal point sources were identified by the Environmental Protection Agency (EPA) as important phosphorus contributors (EPA, 1975).

Even though municipal point source problems were apparent, many Southwestern Wyoming communities could not achieve enough points under the construction grants priority point system to qualify for the "201" grants needed to finance plant improvements. Therefore, the Southwestern Wyoming Water Quality Planning Association (SWWQPA) applied a significant portion of the 208 funds to Step I Facility Plans. Evanston, Granger, Lyman, Mountain View, Jamestown-Rio Vista, South Superior, and Wamsutter completed or are scheduled to complete Facility Plans under the 208 program. An Engineering Assessment for Cokeville was also funded by the 208 program.

Great strides have been made toward improving wastewater effluent quality through the efforts of the Association and some larger communities who have been able to obtain 201 grants. However, as shown on Table 5-3, many municipal dischargers have not complied with the Federal secondary effluent treatment requirements which went into effect on 1 July 1977. Some communities have not received grants needed to design and construct new facilities, other facilities are now in the design and construction phase, and some facilities are just not operating properly.

Table 5-4 lists the construction grant priorities for Fiscal Year 1978. Three communities in the study area are seeking funds. They include Kemmerer-Diamondville (Priority #13), South Superior (Priority #21), and Fort Bridger (Priority #28). Kemmerer-Diamondville and South Superior will probably receive Federal funds for Step 2 this year and Step 3 next year. Fort Bridger will probably receive funds for Step 1 this year.

Brief remarks about each discharger in the study area are made below. The dischargers have been grouped according to the basin to which they discharge. The basins are shown on Figure 1-2. The Bitter Creek Subbasin and Blacks Fork Subbasin of the Green River Basin have been considered separately because of the large number of wastewater discharges in those areas.

Green River Basin (except for two subbasins)

- Green River. This facility is one of the major discharges in the study area. A new sewage treatment facility has been

Table 5-2

SECONDARY TREATMENT STANDARDS

Parameter	Standard
Biochemical Oxygen Demand (5-Day)	
Monthly arithmetic mean	30 mg/l
Weekly arithmetic mean	45 mg/l
Suspended Solids	
Monthly arithmetic mean	30 mg/l
Weekly arithmetic mean	45 mg/l
Fecal Coliform	
Monthly geometric mean	200/100 ml
Weekly geometric mean	400/100 ml
pH	6.0-9.0

Reference: Federal Register. August 17, 1973. Vol. 30, #159, pg 22298.

Table 5-3

STATUS OF MUNICIPAL COMPLIANCE WITH SECONDARY TREATMENT STANDARDS (As of August 1, 1977)

Municipality	NPDES #	Step #	Compliance With Secondary Treatment Standards	Target Compliance Date
Cokeville	0021032		Yes	
Evanston	0020095	(1)	Yes	
Fort Bridger	0022071		Yes	
Kemmerer-Diamondville	0020320 0020303	1	No	?
Granger	0022373	(1)	No	Fall 1978
Green River	0020443	3	No	1978
LaBarge	0022080	3	?	?
Lyman	0020117	(1)	No	Fall 1978
Mountain View	0022896	(3)	No	Fall 1977
Rock Springs	0022357	3	No	1978 or 1979
South Superior		(1)	No	?
Thayne	0025917	3	No	?
Wamsutter	No Discharge	(1)	Yes	

Note: Numbers in parentheses refer to Facility Plans funded by 208 program.

Table 5-4

CONSTRUCTION GRANT OBLIGATIONS FOR FY-1978

Priority	Name	Grant	Remarks
1	Rawlins	$ 3,320,000	
2	Casper	0	
3	Thayne	$ 219,000	
4	Jackson	$ 1,930,000 (1) $ 3,460,000	
5	Green River	0	Under construction
6	Cowley	0	
7	Thermopolis	0	
8	Rock Springs	0	Under construction
9	Rock River	$ 259,000	
10	Glendo	$ 198,000	
11	Powell	$ 270,000	
12	Buffalo	$ 1,650,000	
13	Kemmerer-Diamondville	$ 562,000	Step I underway, Steps II and III funding sought
14	Sheridan	$ 2,200,000	
15	Laramie	$ 4,430,000	
16	Upton	$ 238,000	
17	Lander	$ 1,670,000	
18	Hulett	$ 177,000	
19	Baggs	$ 177,000	
20	Mills	$ 69,000	
21	South Superior	$ 15,000	Step I complete under 208, Step II funding sought
22	Wheatland	$ 25,000	
23	Mountain View	0	Step I complete under 208, under construction with EDA funds
24	Moorcroft	$ 18,000	
25	Medicine Bow	$ 12,000	
26	Worland	$ 20,000	
27	Pinedale	$ 18,000	
28	Fort Bridger	$ 18,000	Step I funding sought
29	LaGrange	$ 12,000	
30	Lingle	$ 12,000	
	TOTAL	$21,009,000	

---

(1) Partial funding of Step III from available funds. The remaining $1,930,000 will be funded from the FY-78 allocation.

constructed to meet the secondary treatment standards. The exfiltration ponds are not working properly and discharge from the ponds frequently exceeds fecal coliform and BOD_5 standards. Two alternatives are being studied: redesign of the ponds or abandonment of the ponds in favor of a point source discharge.

- Jamestown-Rio Vista. Individual waste treatment facilities are in use in this area with no surface discharges monitored. This water and sewer district has a Step 1 Facility Plan prepared under this study, and the district is now studying the alternatives for a central treatment facility.
- LaBarge. The lagoon system has just started to discharge. No water quality data have been taken on the discharges. However, given the detention time in the lagoons, the discharges are likely to meet secondary treatment quality standards.

Bitter Creek Subbasin

- B&B Mobile Home Park (Reliance). The facility has a discharge permit, but no discharge has been observed.
- Bechtel-Reliance Trailer Court. The facility is achieving BPT except for occasional suspended solids excesses caused by algae discharges.
- Clearview Acres (west of Rock Springs). Violations of the NPDES permit in May 1976 and March 1977. The Department of Environmental Quality filed court action in March 1977. No discharge was observed during the summer of 1977.
- Husky Truck Stop (west of Rock Springs). The package treatment plant is essentially inoperable. Violations of fecal coliform, total suspended solids, and BOD_5 standards have been frequent. The facility is on a NPDES compliance schedule.
- Rock Springs. This facility is the largest wastewater discharger in the study area. Violations of the fecal coliform standard are frequent, while violations of BOD_5 and total suspended solids are occasional. The present facility cannot achieve BPT. A contract for construction of a new mechanical plant has been awarded; completion is scheduled for late 1978.
- Silver Dollar Motel. The facility has a discharge permit, but no discharge has been observed.
- South Superior. Frequent violations of all standards have occurred. A Step 1 Facility Plan is completed. The town

has applied for grant money to construct a new treatment facility.

- Sweetwater County Airport. The facility has a discharge permit, but no discharge has been observed.

- Volcic Trailer Park. The facility has a discharge permit, but no discharge has been observed.

- Western Hills Trailer Park. The facility has a discharge permit, but no discharge has been observed.

- White Mountain Village. The facility is operating at less than 5 percent of capacity. It is achieving secondary quality and occasionally tertiary quality effluent.

- Wyoming Highway Department (Bitter Creek rest area). In compliance with discharge permit as of December 1975.

Bridger Valley Subbasin

- Fort Bridger. Occasional violations of the fecal coliform standard have occurred. The system is a single-cell lagoon with some capability for chlorinating the discharge. The capacity is not sufficient to meet projected future growth.

- Granger. Frequent violation of total suspended solids, BOD_5, and fecal coliform standards have occurred. A Step 1 Facility Plan and design have been completed, and the facility is now under construction. The source of funds for the design and construction is the U.S. Economic Development Agency (EDA).

- Kemmerer-Diamondville. The facility is one of the major dischargers in the Green River Basin. Frequent violations of fecal coliform, BOD_5, and total suspended solids standards have occurred. The Step 1 Facility Plan is under final review by the State of Wyoming. They are awaiting funds for design and construction.

- Lyman. Frequent violations of the fecal coliform standard and occasional violations of the suspended solids standard have occurred. The Step 1 Facility Plan has been completed as part of this study. The town has received funds from EDA and the sewage treatment facility is under construction to meet the needs of a population of 4,000.

- Mountain View. Frequent violations of fecal coliform, BOD_5 and suspended solids standards have occurred. The town is virtually without a treatment system. The Step 1 Facility Plan is complete, and the town presently is constructing a three-cell lagoon with EDA funds to meet the discharge standards; the scheduled completion date is fall of 1977.

- **Opal.** The facility has had no observed discharge.

Great Divide Basin

- **Baroil.** The facility has had no observed discharge.
- **Wamsutter.** The facility has had no observed discharge. A Step 1 Facility Plan was completed because of a concern about capacity to meet the projected growth in the area.

Bear River Basin

- **Cokeville.** The facility has been in compliance since March 1976. An Engineering Assessment report was prepared for the town under this study.
- **Evanston.** The facility has been in compliance since summer 1976. Operations and maintenance changes were made at that time. The Step 1 Facility Plan is to be completed as part of this study. The purpose of the plan is to address issues associated with growth.

Snake River Basin

- **Thayne.** This facility has been discussed earlier under "Mining and Industrial Discharges."

Dairies and Feedlots

Livestock production is by far the most important agricultural business in the Green River Basin in terms of sales. However, dairies are rare in the basin. Only 0.3 percent of the estimated 400,000 livestock in the basin are dairy cows and calves. Feedlots are also rare. Most of the cattle and sheep are sold as feeders and shipped outside the basin for fattening and slaughter. A few sheep operations hold lambs long enough to fatten them and ship them directly to slaughter. Runoff from the few dairies and feedlots in the basin is not expected to cause significant regional water quality problems.

Stack Emissions

The connection between air pollution and water pollution is becoming apparent in many areas. A possible source of salinity in the waters of the study area is the stack emissions from the two large power plants, Jim Bridger and Viva Naughton.

The two plants discharge into the air respectively 37,000 tons and 33,000 tons per year of sulfur dioxide. This gas dissolves in rain and comes down as sulfuric acid, which can increase the sulfate loads carried by the streams in the area. The influence of the stack emissions on sulfate loads in the streams appears to be small. The stack emissions, when converted to sulfate, are equal to 11 percent of the total sulfate load generated within the portion of the Green River Basin in the study area. However, because of the commonly strong winds in the area and the infrequency of rainfall, the sulfur dioxide emitted by the plants will be dispersed broadly and some will come down in areas outside of the study area. Thus, the actual sulfate loadings to the Green River Basin from stack emissions will be somewhat less than 11 percent.

The sulfate loadings from the two plants will be even less in the future. Sulfur dioxide emissions at the two plants will be reduced by 50 percent under the current compliance schedule and permits issued by the Air Quality Division of the Wyoming Department of Environmental Quality.

No other significant air pollution sources which might impact water quality were identified in the area.

Springs

Springs contribute large amounts of salinity in the Colorado River Basin. However, the identified salinity load from springs in the Green River Basin is insignificant to the total salinity load. Reagen Spring, located near the Interstate 80 bridge over Muddy Creek, discharges 730 tons per year, (EPA, 1972). No other important discharges from springs have been identified in this study, unless the seeps in the Big Sandy River between Simpson Gulch and Gasson Bridge are considered to be springs. As noted earlier in this chapter, these seeps are estimated to deliver roughly 100,000 tons per year to the Green River system.

Nondischarging Wastewater Ponds

All saline industrial and mining discharges in the study area have been controlled. However, nondischarging municipal and industrial facilities may increase salinity in surface waters by seepage from evaporation ponds. Municipal ponds are all located near stream courses so that seepage from these ponds travels a short distance before discharging to a stream course. The increase in salinity caused by these ponds is probably slight.

Some industrial nondischarging ponds lie at a considerable distance from stream courses and in areas of relatively saline soils. Seepage from these ponds may result in greater salt loads being carried by ground water to the surface waters. The case of industrial nondischarging ponds is investigated more closely in the section entitled "Salinity Loadings from Point Sources."

POLLUTANT LOADINGS FROM POINT SOURCES

The previous section described the point sources and assessed their importance to pollution levels found in the streams and reservoirs of Southwestern Wyoming. Some of the point sources may be important contributors of phosphorus, salinity, fecal coliform and oxygen-demanding material. These sources are discussed in more quantitative detail in this section of the Technical Report.

Phosphorus Loadings from Point Sources

Table 5-1 listed the six types of point sources possibly impacting waters in the study area. Of these six types of point sources, only municipal discharges contribute significant amounts of phosphorus to surface waters. Point source phosphorus loadings have been derived from an effluent flow of 100 gallons per capita per day and an effluent concentration of 10 mg/l for all treatment facilities. The estimates of flow and concentration are based on adequate flow data but on only three measurements in the study area of total phosphorus in the effluent and four of dissolved reactive phosphorus.

Approximately 43,000 people are served by municipal wastewater treatment facilities in the areas tributary to Flaming Gorge Reservoir and within the study area. Based on the assumptions stated above, the total phosphorus loading to Flaming Gorge Reservoir from municipal wastewater treatment facilities is 66 tons per year. The Rock Springs and Green River plants are estimated to deliver 48 tons of phosphorus per year, which is approximately 73 percent of the total point source loading. The remaining plants along Bitter Creek and the Green River are estimated to deliver 6 tons per year, while the Blacks Fork drainage delivers an estimated 12 tons of phosphorus per year from point sources.

Salinity Loadings from Point Sources

The point sources which have been studied for their impact on salinity loads in the Green River Basin are industrial and mining discharges, stack emissions, springs, and nondischarging municipal and industrial wastewater ponds. The tentative conclusion of this study is that point sources have little impact on the salinity loads. Industrial and mining discharges, stack emissions, springs and nondischarging municipal ponds were dismissed as important salinity sources in previous sections.

The case of industrial nondischarging ponds is investigated more closely in this section because some ponds lie at a considerable distance from stream courses and in areas of relatively saline soils. Seepage from the trona ponds may discharge either to the Green River between Big Island and the Town of Green River or to the Blacks Fork between Lyman and Little America. Surface and subsurface flows from the wastewater treatment ponds at the Viva Naughton Power Station near Kemmerer discharge to Little Muddy Creek.

Changes in salt loads through the stream stretches called out above are shown on Table 5-5 for the low-flow months (September through February). It was assumed that the effect of seepage from industrial ponds would be most noticeable at this time of the year because of the absence of other effects such as surface runoff and irrigation return flows. As shown on the table, the net impact of the trona ponds may be to contribute up to 22,000 tons per year of salt to the Green River system. A more detailed ground water analysis is required to assess more accurately the impact of the trona ponds. The data indicate that these ponds may actually be reducing salt loads in the Green River system by diversion and consumption of relatively high saline water.

Table 5-5

EFFECT OF NONDISCHARGING INDUSTRIAL PONDS ON SALINITY

Upstream Station	Instream Load (tons/day)	Downstream Station	Instream Load (tons/day)	Gain in Stretch (tons/day)	Gain in Stretch (tons/year)	Possible Salinity Source	Salt Reduction from Industrial Diversions (tons/year)	Maximum Possible Gain in Salinity Due to Industrial Ponds (tons/year)
Green River near Big Island (9/74-2/76)	1016	Green River near Green River (9/74-2/75)	1090	71	27,000	Trona Ponds	5000	22,000
Green River near Big Island (9/75-2/76)	978	Green River near Green River (9/75-2/76)	1012	34	12,000	Trona Ponds	5000	7000
Blacks Fork near Lyman (9/75-2/76)	476	Blacks Fork near Little America (9/75-2/76)	452	0	0	Trona Ponds	5000	-5000
Headwaters, Little Muddy Creek	0	Little Muddy Creek Near Glencoe (9/75-2/76)	13	13	5000	Viva Naughton Power	11,000	-6000

The water quality data also indicate that the diversion and consumption of moderately saline water at the Viva Naughton Power Station may more than offset salinity gains from seepage. Therefore, the effect of the power station may be actually to reduce salt loads discharged from the study area. Again, however, an analysis of the hydrogeology in the area would permit a more accurate assessment of its impact.

Other Contaminant Loadings from Point Sources

In addition to salinity and phosphorus, fecal coliform and dissolved oxygen were identified as widespread water quality problems in Chapter 3. Water quality monitoring data suggest that many of the high fecal and low dissolved oxygen concentrations are directly or indirectly attributable to poor quality effluent from municipal wastewater treatment plants.

NPDES standards for fecal coliform are frequently violated at the following plants--Green River, Husky Truck Stop, Rock Springs, South Superior, Granger, Kemmerer-Diamondville, Lyman, and Mountain View. The approximate locations of these eight plants are shown on Figure 5-7. Also shown on Figure 5-7 are the locations with the highest fecal coliform concentrations. In most cases, these locations are just below the outfalls of the eight plants mentioned above. The juxtaposition of plant effluents with high fecal coliform concentrations and instream sampling locations with highest fecal coliform concentrations implicates municipal wastewater treatment plants as the major fecal coliform source in the study area.

A comparison of empirical instream fecal coliform concentrations based on effluent loadings with observed instream concentrations further proves the importance of municipal wastewater treatment plants as a fecal coliform source. Table 5-6 lists four instream locations and the major municipal treatment plants contributing to the fecal coliform loadings at those locations. Empirical fecal coliform concentrations have been calculated at those four locations by assuming average instream flows, point source flows equal to 100 gallons per capita per day, and point source fecal coliform concentrations of 1 million colonies per 100 milliliters. These flows and concentrations closely approximate those found in the effluents of the Rock Springs, Green River, and Kemmerer plants. As shown on the table, the point sources can more than account for observed fecal coliform concentrations at those four locations. Therefore, it appears that municipal wastewater treatment plants appear to be the most important fecal coliform sources in this study area.

Municipal wastewater treatment plants also appear to be linked directly and indirectly to many of the dissolved oxygen problems in the study area. NPDES standards for BOD_5 are frequently violated at the following plants--Green River, Husky Truck Stop, South Superior, Granger, Kemmerer-Diamondville, and Mountain View. The approximate locations of these six plants are shown on Figure 5-8. Also shown on Figure 5-8 are the locations of dissolved oxygen problems. Low dissolved oxygen concentrations occur in the Hams Fork below the Kemmerer area and in the Green River below the Town of Green River. The high BOD_5 concentrations in the plant effluents of Kemmerer-Diamondville, Green River, Husky Truck Stop, and South Superior

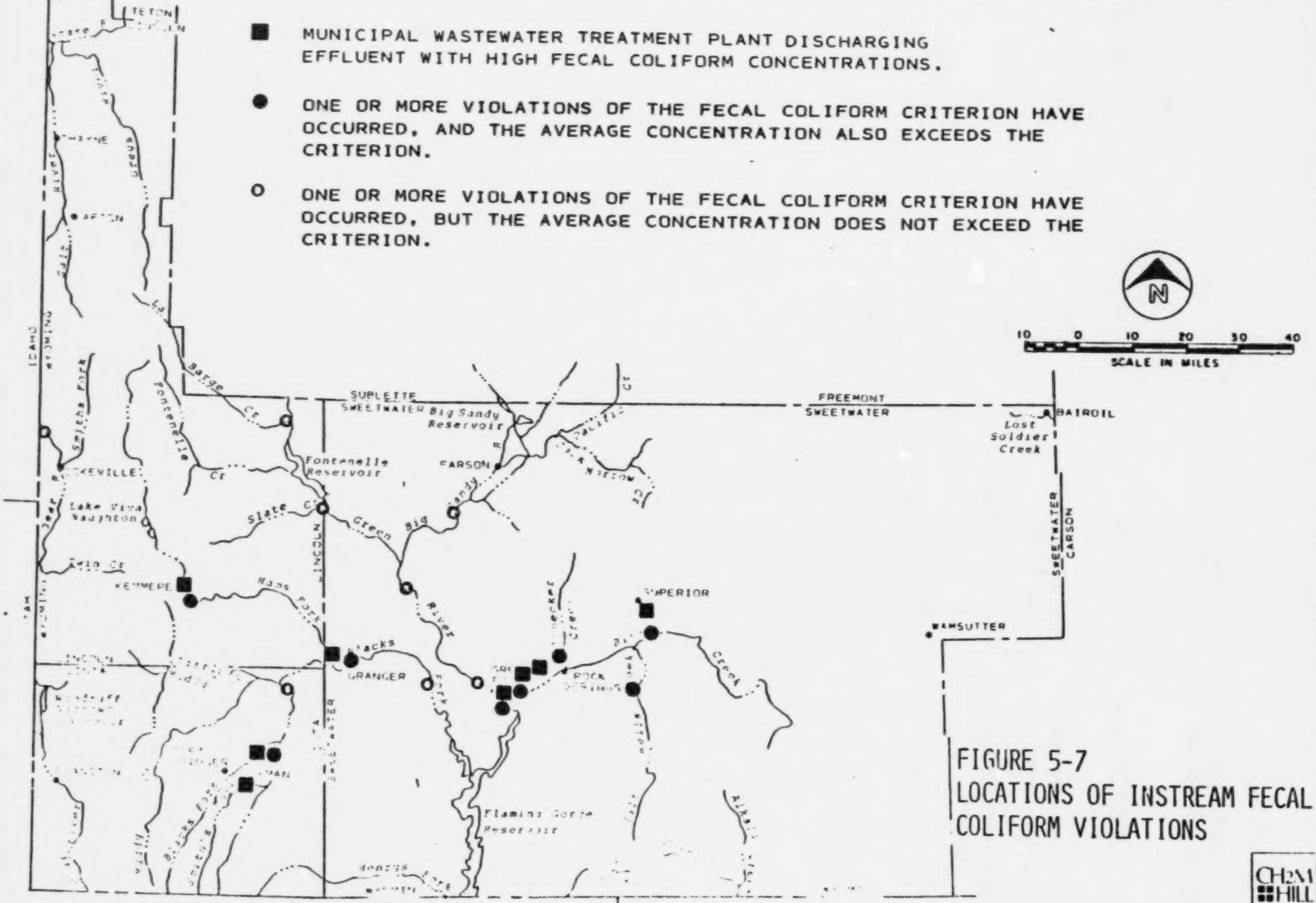
■ MUNICIPAL WASTEWATER TREATMENT PLANT DISCHARGING EFFLUENT WITH HIGH FECAL COLIFORM CONCENTRATIONS.
● ONE OR MORE VIOLATIONS OF THE FECAL COLIFORM CRITERION HAVE OCCURRED, AND THE AVERAGE CONCENTRATION ALSO EXCEEDS THE CRITERION.
○ ONE OR MORE VIOLATIONS OF THE FECAL COLIFORM CRITERION HAVE OCCURRED, BUT THE AVERAGE CONCENTRATION DOES NOT EXCEED THE CRITERION.
N
10 0 10 20 30 40
SCALE IN MILES
TETON
AFTON
IDAHO
WYOMING
Smiths Fork
La Barge Cr
Fontenelle Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Slate Cr
Green
Big Sandy
River
Lake Viva Naughton
KEMMERER
Hams Fork
LINCOLN
SWEETWATER
GRANGER
Blacks Fork
ROCK SPRINGS
SUPERIOR
Creek
Flaming Gorge Reservoir
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
UTAH

FIGURE 5-7
LOCATIONS OF INSTREAM FECAL COLIFORM VIOLATIONS

CH2M HILL

Table 5-6

COMPARISON OF OBSERVED FECAL COLIFORM CONCENTRATIONS WITH EMPIRICAL CONCENTRATIONS BASED ON POINT LOADINGS

Location	Contributing Point Source	Observed Average Concentration (#/100 ml)	Empirical Concentration (#/100 ml)
Green River near Green River	Rock Springs Green River	741	3000
Smiths Fork near Lyman	Mountain View	1017	1200
Hams Fork near Diamondville	Kemmerer-Diamondville	2300	5700
Blacks Fork near Little America	Mountain View Lyman Kemmerer-Diamondville Granger	940	3500

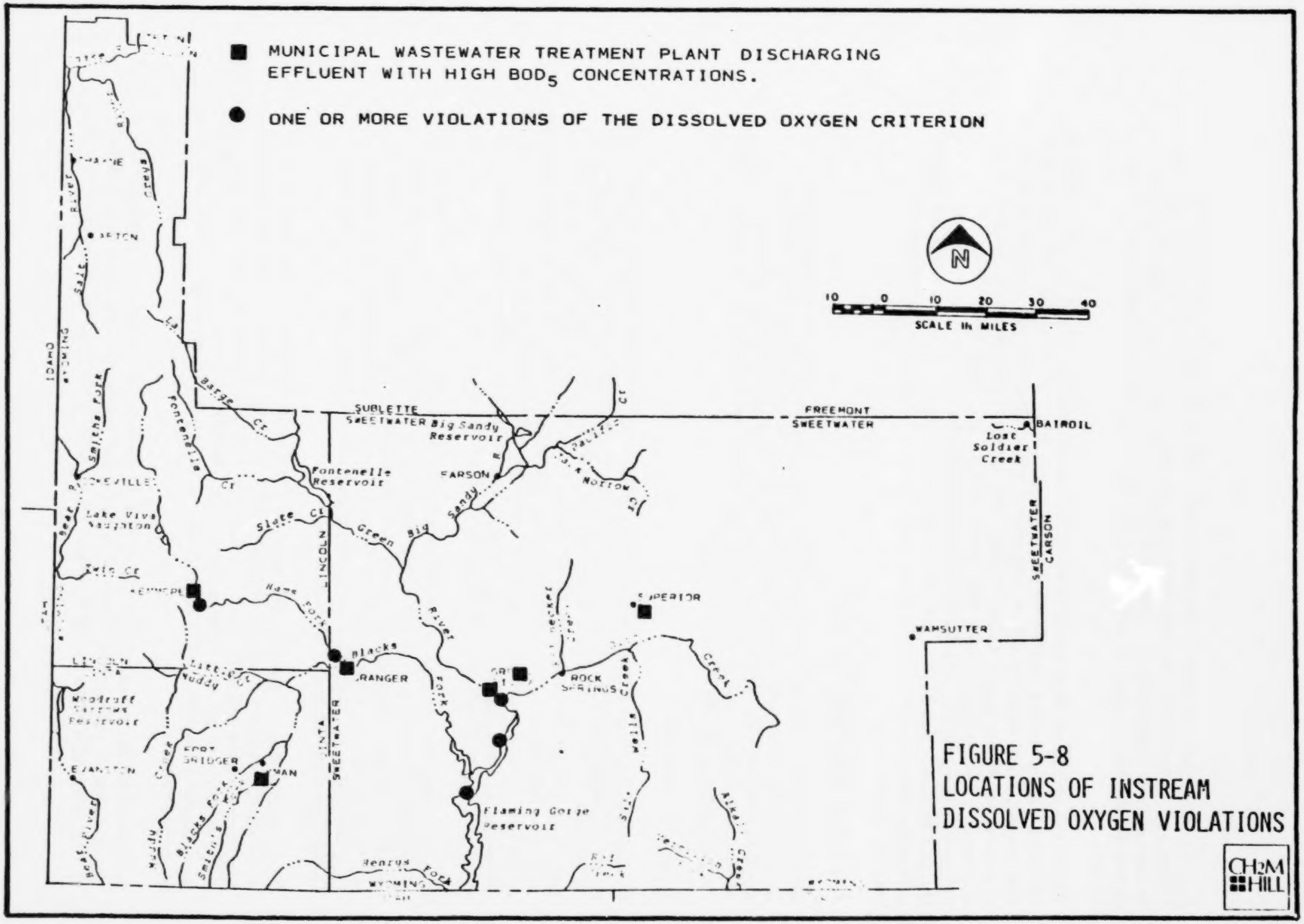
■ MUNICIPAL WASTEWATER TREATMENT PLANT DISCHARGING EFFLUENT WITH HIGH BOD5 CONCENTRATIONS.
● ONE OR MORE VIOLATIONS OF THE DISSOLVED OXYGEN CRITERION
N
10 0 10 20 30 40
SCALE IN MILES
IDAHO
WYOMING
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
SWEETWATER
CARSON
LINCOLN
SWEETWATER
UINTA
SWEETWATER
WYOMING
UTAH
BAIROIL
Lost Soldier Creek
WAMSUTTER
SUPERIOR
ROCK SPRINGS
FARSON
Big Sandy Reservoir
Fontenelle Reservoir
Fontenelle Cr
La Barge Cr
Slate Cr
Green River
Big Sandy
Hams Fork
Blacks Fork
GRANGER
KEMMERER
COKEVILLE
Lake Viva Naughton
Twin Cr
Smiths Fork
Bear River
Salt River
AFTON
THAYNE
Crow Creek
Woodruff Narrows Reservoir
EVANSTON
FORT BRIDGER
Muddy Creek
Little Muddy Cr
Smith's Fork
Flaming Gorge Reservoir
Henrys Fork
Pacific Cr
Little Sandy
Killpecker Creek
Bitter Creek
Salt Wells Creek
Alkali Creek
Vermillion Creek

FIGURE 5-8
LOCATIONS OF INSTREAM
DISSOLVED OXYGEN VIOLATIONS

CH2M HILL

may be important causes of the dissolved oxygen problems at these two locations. A Streeter-Phelps dissolved oxygen sag analysis should be run to assess how important are the high BOD_5 concentrations in the effluents to the dissolved oxygen problems in the lower Hams Fork and lower Green River.

The plant effluents may be indirectly linked to the dissolved oxygen problems because they provide nutrients for algal growth. When algae respire or die and decay, they require large amounts of dissolved oxygen. Algal blooms are common in the lower Green River, the Green River arm and upper reaches of Flaming Gorge Reservoir, the lower Hams Fork, and the Snake River arm of Palisades Reservoir. Municipal treatment plants are located above all those reaches. Thus, the phosphorus and nitrogen loadings from the plant effluents may be indirect but important factors leading to the dissolved oxygen problems.

NONPOINT SOURCES

From the above discussion it appears that point sources are not the major contributors to the salt and phosphorus loads found in the area streams. Most of the loadings can therefore be attributed to nonpoint sources. The 13 possibly important nonpoint sources identified in this study were listed on Table 5-1 and are discussed below.

Geologic Erosion

Suspended sediment may be adversely affecting fish populations in the study area. Suspended sediment may also play an important part in water quality in the Green River Basin as a carrier of phosphorus, metals, fecal coliform, and soluble salts. The association of the first three contaminants with sediment has been widely documented. Recently, the Bureau of Land Management has found a correlation between salt and sediment loads in the Upper Colorado River Basin and suggested that dissolution of some of the eroded material may be a major process contributing to instream salinity.

The process which delivers sediment to the streams is erosion. Two types of erosion have been defined in the study area, geologic erosion and accelerated erosion. Geologic erosion is influenced by natural factors, such as the type of soil, the steepness of slopes, and the intensities and frequencies of rainfalls. Sediment, phosphorus, and salt loadings from geologic erosion are estimated in this section.

On the other hand, accelerated erosion in the study area is concerned with man-related factors such as overgrazing, mining, construction, cultivation, and recreational vehicle use. These activities can greatly increase geologic erosion rates and create suspended sediment problems in the streams. Contaminant loadings from accelerated erosion are discussed in the following four sections.

A few observations on the Flaming Gorge Reservoir watershed indicate the importance of geologic erosion as a sediment source. The first observation is that the watershed is very large. Approximately 15,000 square miles in

Utah and five Wyoming counties are tributary to Flaming Gorge Reservoir. Several reservoirs are scattered throughout the watershed, and these trap some of the sediment before it reaches Flaming Gorge Reservoir. Nevertheless, the portion of the Flaming Gorge Reservoir watershed below those reservoirs covers about 10,000 square miles, most of which is in the study area. The approximate extent within the study area is shown on Figure 5-9. Free-flowing streams can deliver eroded sediment and its associated contaminants from this large area to Flaming Gorge Reservoir.

The second observation is that geologic erosion has been active in carving fantastic land forms in the study area. Erosion relief is dramatic in the lower end of the Bitter Creek subbasin, in some parts of Bridger Valley, and in the vicinity of Flaming Gorge Reservoir itself. The sediment eroded in these areas used to be carried out of Wyoming by the Green River. Now, however, it is trapped behind Flaming Gorge dam. The phosphorus carried by the sediment is also now trapped in the reservoir.

Methodology. Salt and phosphorus loads from geologic erosion have been estimated for the portion of the Green River Basin in the study area (see Figure 5-9). The method for calculating these loads is summarized briefly below:

1. Influence areas, those areas capable of producing and delivering eroded material, were defined.

2. General erosion rates, taken from the Type IV study (1) for the Green River Basin, were applied to the influence areas to determine empirical sediment loads in each reach.

3. Soil types in the Green River Basin, defined in the Type IV study, were characterized chemically by comparing them to soil types in Sweetwater and Fremont Counties on which chemical data were available.

4. Loadings of phosphorus, calcium, and sodium to streams from erosion were calculated by applying the chemical data on soils to the empirical sediment loads in each reach.

It is important not to exaggerate the precision of these calculations. Assumptions and extrapolations of existing data are made during each of the four steps described above. However, although admittedly imprecise, the numbers can indicate the relative contribution of geologic erosion to phosphorus and salinity loadings. They can also be used to identify those areas which are delivering the largest loadings from geologic erosion.

Areas capable of delivering significant sediment loads to the Green River were assumed to be the moderately to steeply sloped lands along perennial

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(1) The Type IV study is a cooperative State and Department of Agriculture venture whose purpose is to identify natural resource problems and develop methods for correcting them.

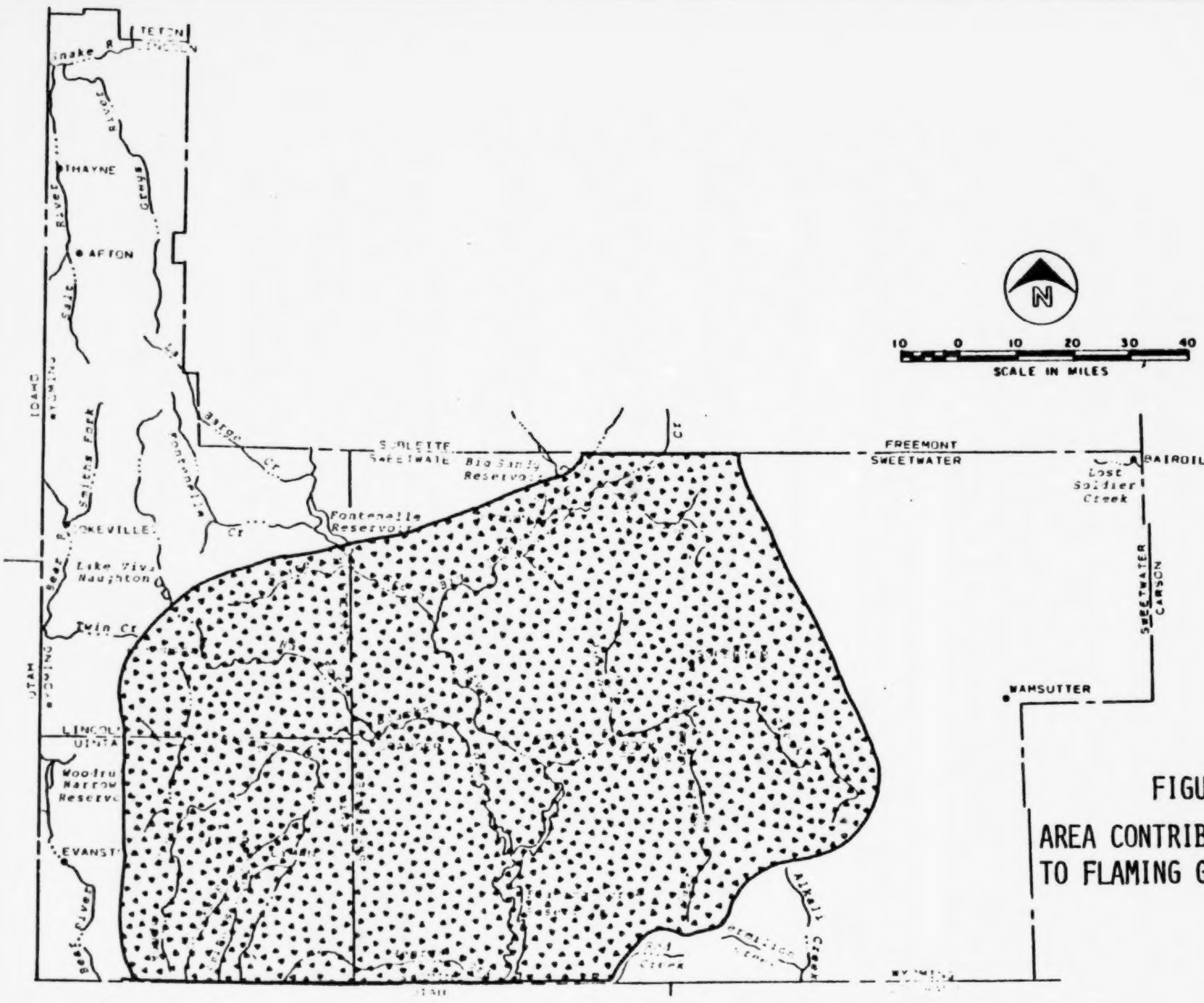
TETON
LINCOLN
Snake R
River
THAYNE
AFTON
Greys
Salt
River
IDAHO
WYOMING
Salt
Smiths Fork
Fontenelle
Cr
Cr
SUBLETTE
SWEETWATER
Big Sandy
Reservoir
Fontenelle
Reservoir
Cr
FREEMONT
SWEETWATER
BAIROIL
Lost
Soldier
Creek
SWEETWATER
CARSON
WAMSUTTER
KEVILLE
Lake Viva Naughton
Twin Cr
UTAH
WYOMING
LINCOLN
UINTA
Woodruff
Narrow
Reservoir
EVANSTON
Bear River
Alkali Creek
Bitter Creek
Creek
UTAH
WYOMING
10
0
10
20
30
40
SCALE IN MILES
N

FIGURE 5-9

AREA CONTRIBUTING SEDIMENT TO FLAMING GORGE RESERVOIR

and intermittent streams. These influence areas cover 22 percent of the Green River watershed in the study area. The remaining 78 percent is assumed not to deliver significant sediment loads because of flat terrain and large distances from stream courses.

The Universal Soil Loss equation was used to calculate geologic erosion rates in the influence areas. The Universal Soil Loss Equation predicts sediment yield (erosion rates) rather than sediment in the streams. However, the assumption is made that all sediment eroded in the influence areas is delivered to the stream courses. This appears to be a reasonable assumption because of the way influence zones have been defined.

One of the variables in the Universal Soils Loss Equation (USLE) is the amount of cover ("C"). Ranges for "C" in the study area are: greasewood and saltbrush, 0.41-0.081; sagebrush and grass, 0.012-0.040; and low sagebrush, 0.040-0.080 (McClellan, 1977). Some of this variation is due to natural conditions such as soil type and climate. However, a significant portion is also due to grazing practices. Overgrazing can significantly reduce cover, thereby increasing erosion. Therefore, some of the sediment loading attributed to geologic erosion in this section is actually caused by overgrazing, which is one of the accelerated erosion sources. The locations of overgrazed lands and the impact of overgrazing on contaminant loadings is discussed in the next section.

Erosion Rates. Figure 5-10 shows the calculated geologic erosion rates in the study area section of the Green River watershed. The most severe erosion is predicted along Killpecker Creek and Red Creek, in the vicinity of Henrys Fork, and in the vicinity of the Green River at its confluence with the Big Sandy River. Extensive areas of moderate erosion include the Upper Bitter Creek, Muddy Creek, and Little Muddy Creek drainages. Smaller areas of moderate erosion occur in the Jack Morrow drainage and on the east side of the Green River between Big Sandy River and Bitter Creek.

A comparison is made on Figure 5-10 of the areas of moderate to heavy geologic erosion and the stream reaches in which fisheries were identified as impaired because of excessive total suspended solids concentrations. In almost every case, the impaired reach lies in or below extensive areas of moderate to heavy geologic erosion. The exception is Big Sandy River, where accelerated erosion sources may be causing the high concentrations.

Several reaches have total suspended solids concentrations which average more than 1000 mg/l, but are not shown as impaired for fisheries only because fisheries is not a designated use on them. These reaches are Lower Bitter Creek, Salt Wells Creek, and Killpecker Creek. Lower Bitter Creek and Killpecker Creek lie in or below areas of high geologic erosion, but Salt Wells Creek does not. Like Big Sandy River, the high total suspended solids concentrations in Salt Wells Creek may be caused by some type of man-induced erosion.

Calculated empirical sediment loadings from geologic erosion are compared with instream suspended sediment loads measured at Blacks Fork near Little America and Green River near Green River on Figure 5-11. Annual sediment

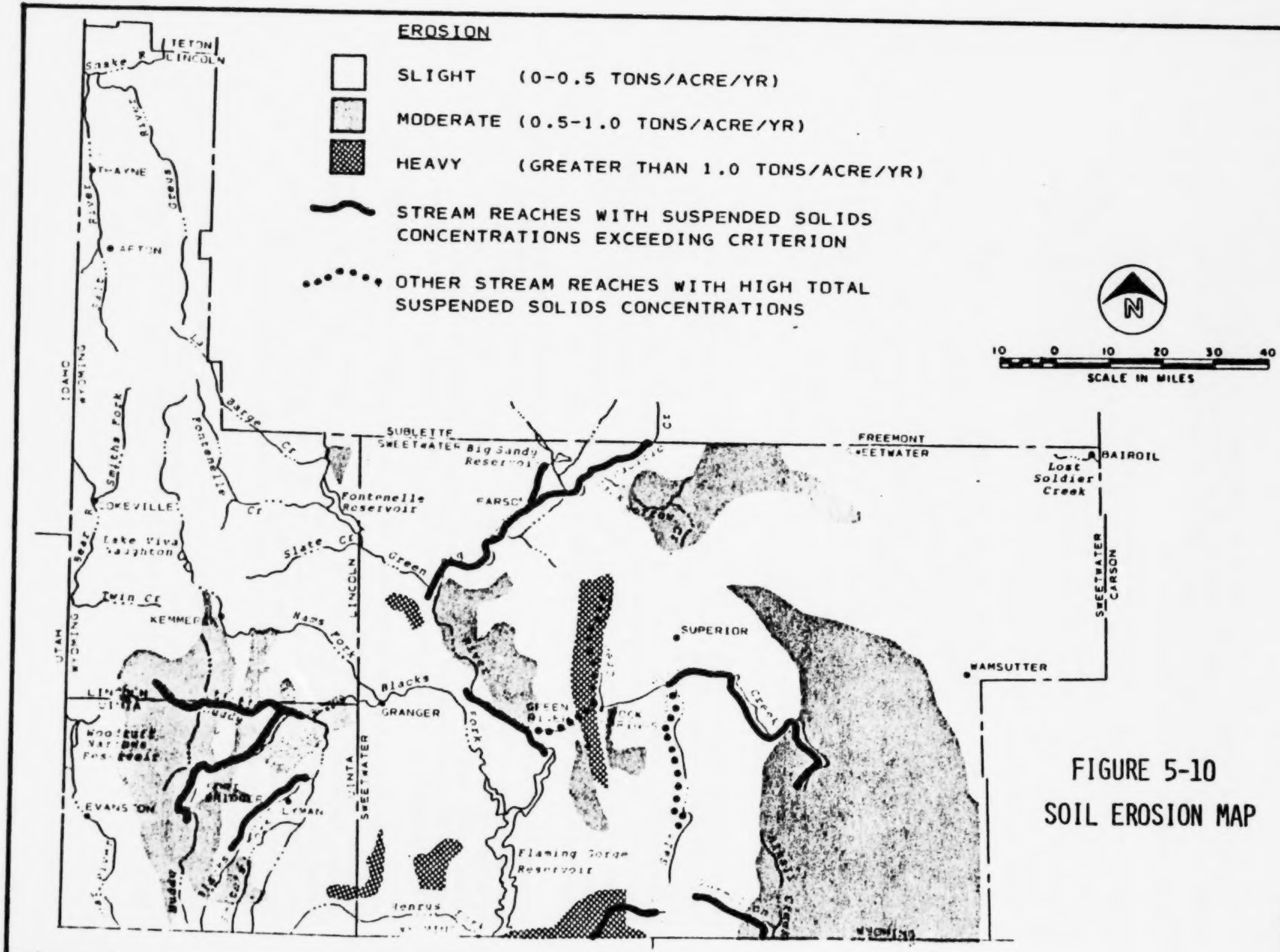
EROSION
SLIGHT (0-0.5 TONS/ACRE/YR)
MODERATE (0.5-1.0 TONS/ACRE/YR)
HEAVY (GREATER THAN 1.0 TONS/ACRE/YR)
STREAM REACHES WITH SUSPENDED SOLIDS CONCENTRATIONS EXCEEDING CRITERION
OTHER STREAM REACHES WITH HIGH TOTAL SUSPENDED SOLIDS CONCENTRATIONS
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
IDAHO
WYOMING
Smiths Fork
Fontenelle Cr
Slate Cr
OKEVILLE
Lake Viva Naughton
Bear R
Twin Cr
KEMMERER
Hams Fork
UTAH
WYOMING
LINCOLN
UINTA
EVANSTON
LYMAN
Blacks
GRANGER
Fork
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Green R
LINCOLN
UINTA
SWEETWATER
GREEN RIVER
Flaming Gorge Reservoir
Henrys
SUPERIOR
Creek
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
WYOMING

FIGURE 5-10
SOIL EROSION MAP

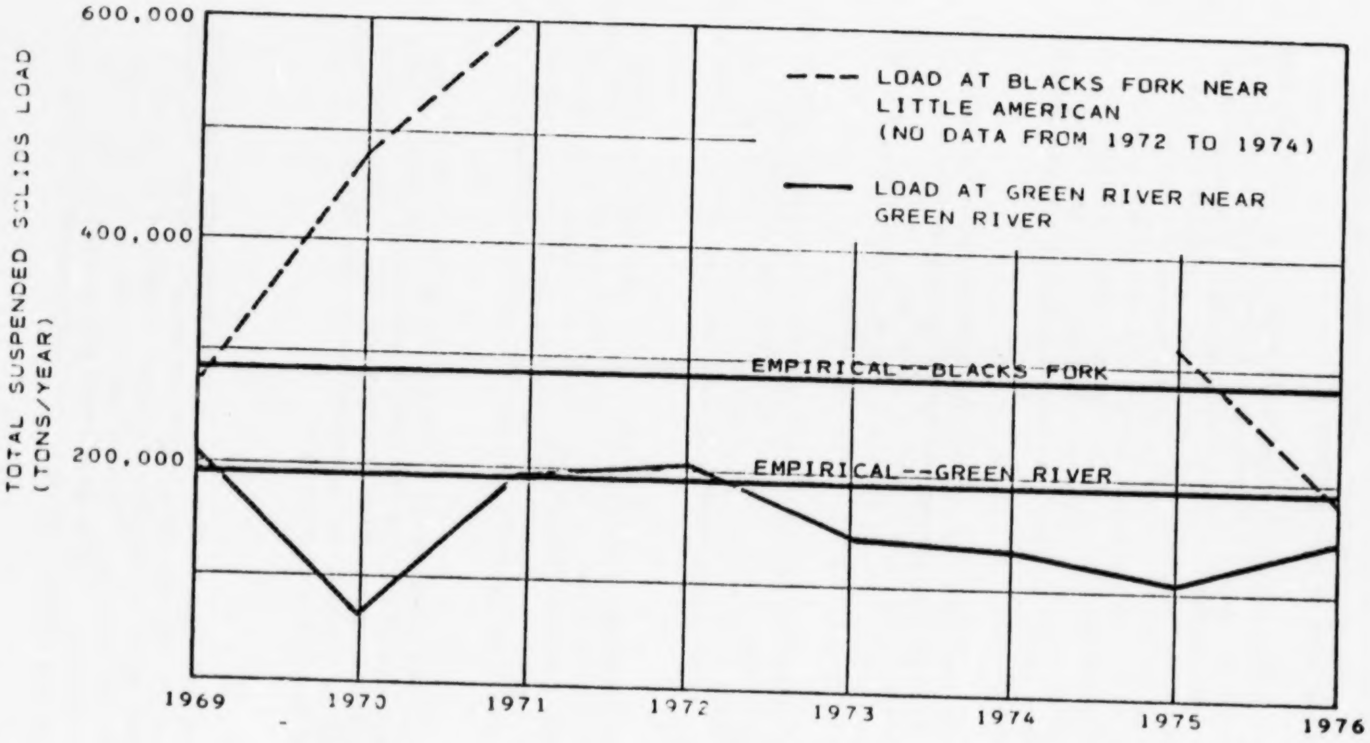

FIGURE 5-11

EMPIRICAL COMPARED TO INSTREAM TOTAL SUSPENDED SOLIDS LOADS

loads at both locations vary considerably. However, the empirical estimate falls in the range of the measured instream sediment loads, and the empirical load estimate at both locations differs by only 30 percent from the average annual instream loads. Therefore, the calculated empirical loadings from geologic erosion appear to account for essentially all the suspended sediment in the streams. (As noted earlier in this section, the empirical loadings also include the effects of overgrazing.)

Phosphorus Loadings. Geologic erosion rates were applied to chemical data on soils from the Eden- Farson area in Sweetwater County and neighboring Fremont County to yield an estimate of the salinity and total phosphorus to be expected from eroded soil of a particular soil type. Chemical information was available on the solubility of cations in the saturation extract and the available phosphorus for each soil type in the two areas. Cation solubility was converted to total dissolved solids by assuming cations to be divided evenly between sodium and calcium and anions to be divided evenly between bicarbonate and sulfate. Available phosphorus was assumed to approximate total phosphorus.

Chemical soils data from the Eden-Farson and Riverton areas were applied to the soils in the study area by comparing soil types (gravelly, loamy, clayey, etc.) in the Eden-Farson and Riverton areas with those in the study area. The erodable soils in the study area were determined to range 0.03-0.08 percent phosphorus and 0.2-1.1 percent soluble cations.

Figure 5-12 indicates those reaches in the study area which have the highest loading rates of phosphorus. These six critical areas for phosphorus include Red Creek, Killpecker Creek, Jack Morrow Creek, and a region containing Lower Muddy Creek, Little Muddy Creek, and the Church Butte reach of the Blacks Fork.

Estimated phosphorus loadings from geologic erosion are listed on Table 5-7 for the five critical reaches tributary to Flaming Gorge Reservoir (excluding Red Creek). The total loading from geologic erosion in these five reaches is 170 tons per year, which is 33 percent of the total empirical phosphorus loading to the reservoir from geologic erosion (including the effects of overgrazing).

Salinity Loadings. Unlike phosphorus, little of the salinity load in the Green River and the Blacks Fork is attributed to geologic erosion. Table 5-8 shows estimated salinity loadings from geologic erosion. These loadings account for 3 percent of the salt load increases within the study area from the Blacks Fork and Green River drainages.

Overgrazing

Overgrazing is one of the four accelerated erosion processes investigated in this report. Overgrazing can reduce ground cover, thereby increasing the erodability of the soils. It can also increase runoff and bring about bank destabilization and erosion. Broad areas of poor range conditions exist within the study area. The largest areas are located in the Bitter Creek drainage, the Big Sandy drainage, the Muddy Creek drainage, and the

FIGURE 5-12
PHOSPHORUS LOADING RATES

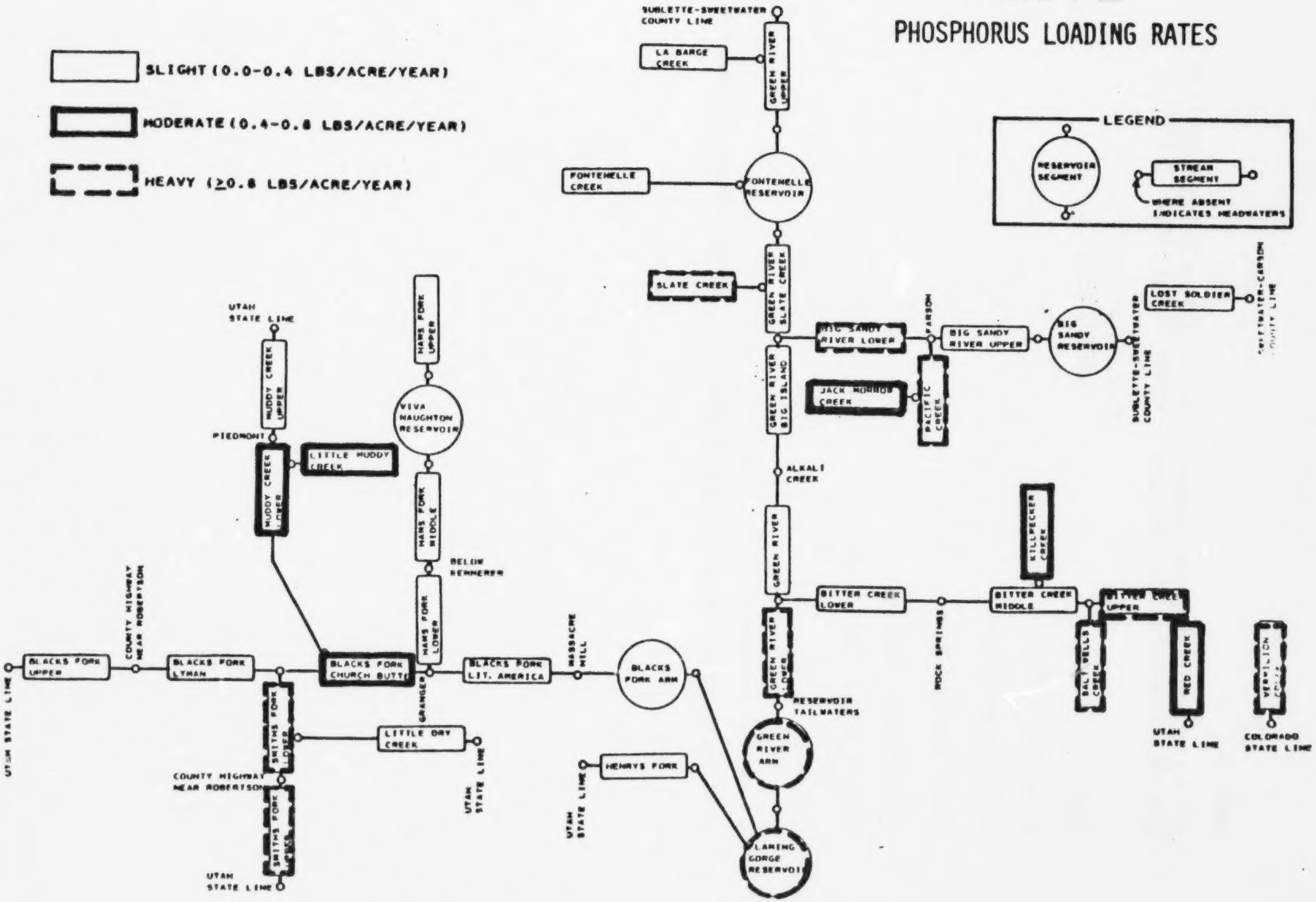
SLIGHT (0.0-0.4 LBS/ACRE/YEAR)
MODERATE (0.4-0.8 LBS/ACRE/YEAR)
HEAVY (≥0.8 LBS/ACRE/YEAR)
LEGEND
RESERVOIR SEGMENT
STREAM SEGMENT
WHERE ABSENT INDICATES HEADWATERS
SUBLETTE-SWEETWATER COUNTY LINE
LA BARGE CREEK
GREEN RIVER UPPER
FONTENELLE CREEK
FONTENELLE RESERVOIR
SLATE CREEK
GREEN RIVER SLATE CREEK
BIG SANDY RIVER LOWER
PARSON
BIG SANDY RIVER UPPER
BIG SANDY RESERVOIR
SUBLETTE-SWEETWATER COUNTY LINE
LOST SOLDIER CREEK
SWEETWATER-CARBON COUNTY LINE
GREEN RIVER BIG ISLAND
JACK MORROW CREEK
PACIFIC CREEK
ALKALI CREEK
GREEN RIVER
KILLPECKER CREEK
BITTER CREEK LOWER
ROCK SPRINGS
BITTER CREEK MIDDLE
BITTER CREEK UPPER
SALT WELLS CREEK
RED CREEK
UTAH STATE LINE
VERMILLION CREEK
COLORADO STATE LINE
GREEN RIVER LOWER
RESERVOIR TAILWATERS
GREEN RIVER ARM
FLAMING GORGE RESERVOIR
HENRYS FORK
UTAH STATE LINE
BLACKS FORK ARM
MASSACRE HILL
BLACKS FORK LIT. AMERICA
GRANGER
HAMS FORK LOWER
BELOW KEMMERER
HAMS FORK MIDDLE
VIVA NAUGHTON RESERVOIR
HAMS FORK UPPER
BLACKS FORK CHURCH BUTTE
MUDDY CREEK LOWER
LITTLE MUDDY CREEK
PIEDMONT
MUDDY CREEK UPPER
UTAH STATE LINE
LITTLE DRY CREEK
UTAH STATE LINE
SMITHS FORK LOWER
COUNTY HIGHWAY NEAR ROBERTSON
SMITHS FORK UPPER
UTAH STATE LINE
BLACKS FORK LYMAN
COUNTY HIGHWAY NEAR ROBERTSON
BLACKS FORK UPPER
UTAH STATE LINE

Table 5-7

ESTIMATED PHOSPHORUS LOADINGS FROM GEOLOGIC EROSION (1) IN THE REACHES WITH THE HIGHEST PHOSPHORUS LOADING RATES

Reach	Phosphorus Loading (tons/year)
Killpecker Creek	10
Jack Morrow Creek	26
Lower Muddy Creek	34
Little Muddy Creek	81
Church Butte-Blacks Fork	19
TOTAL	170

---

(1) As noted in the text, these loadings include the effects of overgrazing.

Table 5-8

ESTIMATED SALINITY LOADINGS FROM GEOLOGIC EROSION

Stretch of River	Total Dissolved Solids Loading (tons/year)
Green River	
Sublette-Sweetwater line to station below Fontenelle	680
Station below Fontenelle to station at Big Island	4,700
Station at Big Island to station below Green River	6,850
Blacks Fork	
Headwaters to station near Lyman	660
Station near Lyman to station near Little America	6,475
Other Direct Tributaries to Flaming Gorge	3,215
TOTAL	22,580 (1)

---

(1) Total dissolved solids increase from all sources is 760,000 tons per year.

Church Butte reach in the Blacks Fork. Although some of these poor range conditions may result from natural causes, most of them probably occur or are worsened because of overgrazing.

Overgrazed conditions may be caused by wild or domesticated animals. Wild animals, particularly wild horses, have received much public attention in the study area because of their impacts on limited water supplies and grazing lands near those water supplies. Wild animals certainly cause some of the poor range conditions; by overgrazing and trampling the vegetation; for example, wild horses overgraze areas along the Big Sandy River and the Green River below Fontenelle Reservoir. However, approximately 90 percent of the wild animals are browsers rather than grazers, and it is the latter who typically cause most of the poor range conditions. By contrast, cattle and sheep are grazers; they greatly outnumber wild horses and other grazing wild animals in the study area. Therefore, cattle and sheep appear to have the larger impact on vegetative cover in the area.

Big Sandy River and Salt Wells Creek were called out in the previous section as having high total suspended solids concentrations but not being located in areas of high geologic erosion rates. These high concentrations may be attributable to poor range conditions caused by overgrazing. SCS has identified 30 miles of serious stream bank and gully erosion along Salt Wells Creek (USDA, 1978). This erosion may be directly caused by overgrazing along the banks or indirectly caused by increased runoff due to overgrazing.

Overgrazing may also be increasing erosion rates in those areas identified in the previous section to have high geologic erosion rates. Figure 4-13, delineates the critical areas with moderate to high geologic erosion rates and poor range conditions. Instream water quality data substantiate the conclusion that the combination of these two factors produces the largest widespread erosional loadings in the study area.

Six critical reaches with high phosphorus loading rates from geologic erosion were identified on Figure 5-12. Two of these reaches, Killpecker Creek and Red Creek, are shown on Figure 5-13 to have generally poor range conditions and heavy erosion rates. Three other critical reaches, Lower Muddy Creek, Little Muddy Creek, and parts of the Church Butte reach in the Blacks Fork, are shown to have generally poor range conditions and moderate erosion rates. The most significant impacts of overgrazing on phosphorus loadings probably occur in these five reaches. The other reach, Jack Morrow Creek, does not have poor range conditions.

The correlation shown on Figure 5-13 between high geologic erosion rates and poor range conditions implies the importance of overgrazing to erosion. Because of this apparent importance, some rough estimates of phosphorus loadings due to overgrazing alone have been made. As with the geologic erosional loading estimates, these numbers must be considered only as ballpark estimates; but they can be useful in indicating the relative importance of grazing practices to phosphorus loadings.

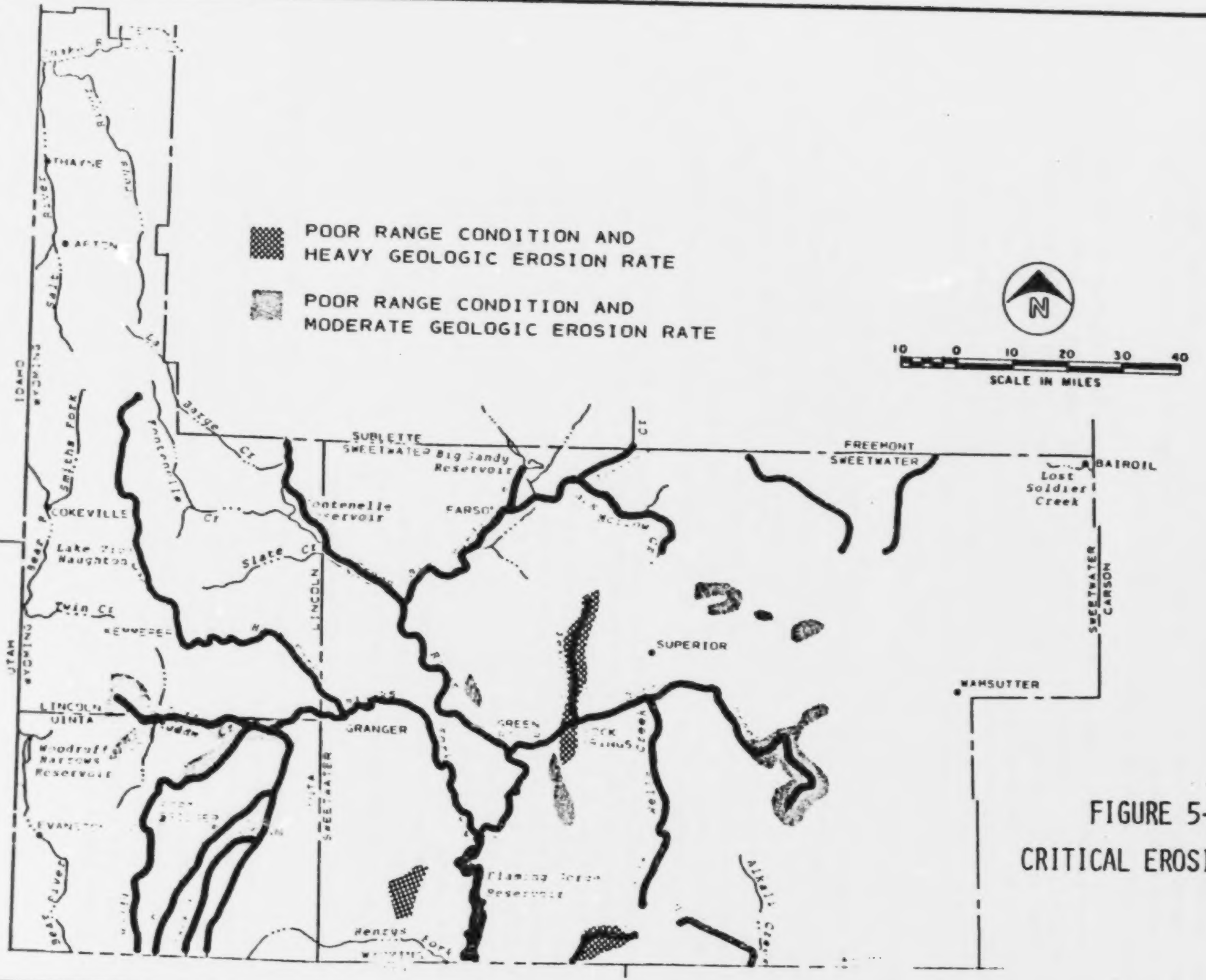
POOR RANGE CONDITION AND HEAVY GEOLOGIC EROSION RATE
POOR RANGE CONDITION AND MODERATE GEOLOGIC EROSION RATE
N
10 0 10 20 30 40
SCALE IN MILES
IDAHO
WYOMING
UTAH
WYOMING
THAYNE
AFTON
Salt River
Smiths Fork
COKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMERER
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
Bear River
La Barge Cr
Fontenelle Cr
Slate Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
Fontenelle Reservoir
FARSON
LINCOLN
UINTA
SWEETWATER
GRANGER
GREEN RIVER
ROCK SPRINGS
Flaming Gorge Reservoir
Henrys Fork
SUPERIOR
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
Alkali Creek

FIGURE 5-13
CRITICAL EROSION AREAS

CH2M HILL

Analysis of SCS data collected in the study area (McClellan, 1977) shows that ground cover is 40-60 percent in areas of poor range conditions and 60-80 percent in areas of good range conditions. Based on these covers, the Universal Soil Loss Equation (USLE) predicts erosion from lands with poor range conditions to be 55-80 percent higher than erosion from lands with good range conditions. The large percentage change demonstrates the impact of overgrazing on geologic erosion rates.

Table 5-9 presents erosion loadings calculated for seven reaches by USLE. Overgrazing is extensive and phosphorus loading rates are moderate to high in these seven reaches. The estimated percentage change (55-80 percent) in geologic erosion rates caused by overgrazing has been used to determine ballpark estimates of loadings due to overgrazing alone. Overgrazing is estimated to increase phosphorus loadings to Flaming Gorge Reservoir by 104-149 tons per year from the seven reaches with extensive overgrazing.

Mining Site Erosion

The location of existing mining sites is shown on Figure 5-14. All the trona mines are underground, while all the coal mines are strip except for the Stansbury mine north of Rock Springs and the Rainbow #8 mine south of Rock Springs. No large erosional loadings are expected from any of the deep mines, particularly since they are located at considerable distances from major stream courses. The concentration of strip mines in the Kemmerer area would appear to have the potential to impact water quality. However, water quality data do not link these mines with any water quality problems.

Extensive oil and gas drilling has occurred in the Green River Basin, particularly in the Salt Wells watershed. This drilling activity can have the same effect as overgrazing by destroying vegetation. Each drilling site is estimated to disturb approximately 3 acres. This disturbed area becomes highly susceptible to accelerated erosion. Although it is difficult to estimate the extent of drilling in the watershed, up to 1,000 sites may have been disturbed over the last 20 years. The drilling activity may be partially responsible for high suspended solids concentrations in Salt Wells Creek, where concentrations average almost 19,000 mg/l during the May-September period. However, because it has disturbed a very limited area, drilling activity is presently estimated to have an insignificant effect on total phosphorus loadings to Flaming Gorge Reservoir.

Construction Site Erosion and Channelization

The population growth in the study area has been dramatic. New construction associated with this growth has increased erosion in two ways. First, construction activity disturbs the soil and removes protective vegetation. Second, runoff typically increases from urbanizing and urban areas, and the stream banks erode until the channel finds a new geometry to handle the increased flows. The high total suspended solids concentrations in Lower Bitter Creek, which average over 12,000 mg/l during the May-September period, may be partially attributable to construction activity in the Rock Springs area.

Table 5-9

ESTIMATED PHOSPHORUS LOADINGS FROM OVERGRAZING

Reach	Loading from Geologic Erosion and Overgrazing (tons/year)	Loading Attributable to Overgrazing Alone (tons/year)
High Phosphorus Loading Rate and Poor Range Conditions		
Killpecker Creek	10	6-8
Lower Muddy Creek	34	19-27
Little Muddy Creek	81	45-65
Church Butte-Blacks Fork	19	10-15
Moderate Phosphorus Loading Rate and Poor Range Conditions		
Upper Bitter Creek	23	13-18
Salt Wells Creek	14	7-11
Lower Big Sandy River	6	3-5
TOTAL	187	103-149 (55-80% of total)

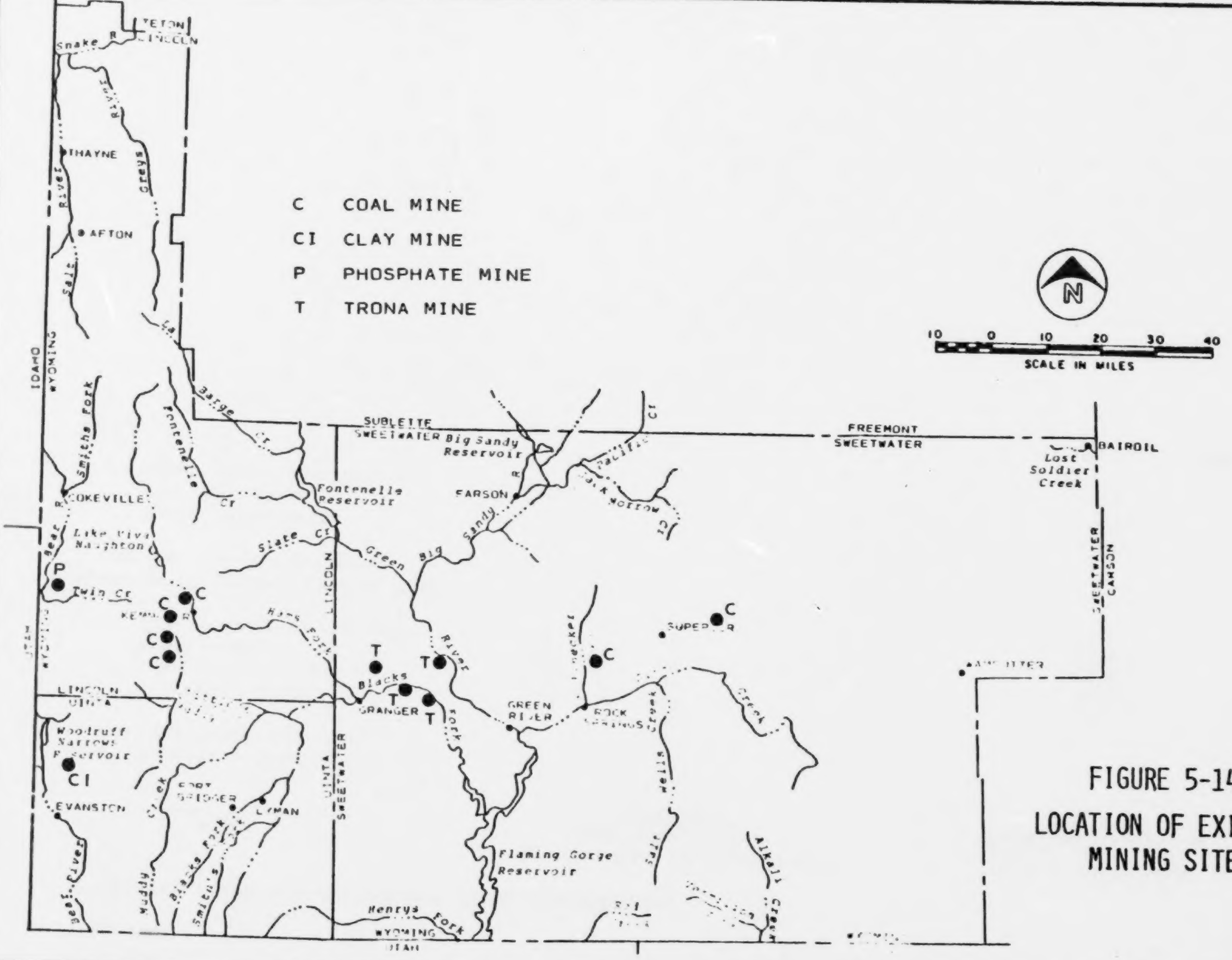
C COAL MINE
CI CLAY MINE
P PHOSPHATE MINE
T TRONA MINE
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
River
Greys
AFTON
Salt
IDAHO
WYOMING
Smiths Fork
Fontenelle
Barge Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
COKEVILLE
Fontenelle Reservoir
FARSON
Sandy
Pacific
Cr
Bear
Slate Cr
Green
Big
SWEETWATER
CARSON
P
Twin Cr
C
C
C
C
Hams Fork
LINCOLN
T
T
River
C
SUPERIOR
C
Blacks
T
T
GRANGER
LINCOLN
UINTA
GREEN RIVER
ROCK SPRINGS
Woodruff Narrows Reservoir
CI
EVANSTON
FORT BRIDGER
LYMAN
UINTA
SWEETWATER
Fork
Flaming Gorge Reservoir
Salt
Alkali Creek
Henrys Fork
WYOMING
UTAH
Bear River
Muddy
Smith's Fork
Blacks Fork

FIGURE 5-14
LOCATION OF EXISTING MINING SITES

CH2M HILL

Even though construction activity may significantly increase erosion rates on land under construction, the area covered by construction is small relative to the total area of the Flaming Gorge Reservoir watershed. A much greater impact of construction-type activity has probably been caused by the channelization of streams. As shown on Figure 5-15, Bitter Creek is a naturally meandering stream pinched between the Union Pacific Railroad, Interstate 80, and Rock Springs urban development. Channel straightening has been a common practice where meanders in the river have endangered structures or private property. When channels are straightened, stream velocities are increased and vertical erosion can take place. This vertical erosion also encourages sloughing from the banks. The increased flow velocities may also have contributed to flood problems in Rock Springs. According to the Type IV study for the Green River Basin, annual flood damages attributed to Bitter Creek amount to $37,000.

Figure 5-15 shows that the railroad also follows much of Lower Muddy Creek. Channelization to protect the railroad bed has also occurred along this stream.

It is probably more than mere coincidence that the highest total suspended solids concentrations occur in the same reaches in which channelization has taken place. It is not possible to quantitatively estimate how much this channelization has added to the total suspended solids and phosphorus loads carried by the streams. Even without channelization, loads in Muddy Creek and Bitter Creek would be high because of the high geologic erosion rates and overgrazing in those drainages. However, the tall and unstable banks, particularly along Bitter Creek, are visible testimony to the vertical erosion promoted by channelization.

Agricultural Runoff

Phosphorus may be delivered from irrigated areas by erosion of banks along irrigation canals and ditches. Erosion has been observed in the Star Valley and the Bridger Valley. Sediment has to be cleared periodically from ditches and canals in these areas in order to ensure proper flow. Much of the eroded sediment probably does not reach the rivers through the irrigation canal systems. Flows are generally too slow in irrigation canals where they meet rivers to carry much eroded sediment. Therefore, erosion along irrigation canals and ditches is considered a local problem which has an impact on individual farmers, but probably has a small influence on the phosphorus loads delivered to the reservoirs.

The Yellowstone-Tongue River 208 Plan for a six-county area in northeastern Montana found an average sediment loading of 65 pounds per acre per year from hay fields and pasture. In the Green River Basin, hay fields and pasture account for most of the irrigated area. If the loading rate determined in the Yellowstone-Tongue River area could be applied to the Green River Basin, the entire irrigated acreage in the Green River Basin delivers 4,000 tons of sediment and 3 tons of phosphorus per year. These loading rates are lower than those from lands in the area which have been left in their natural state.

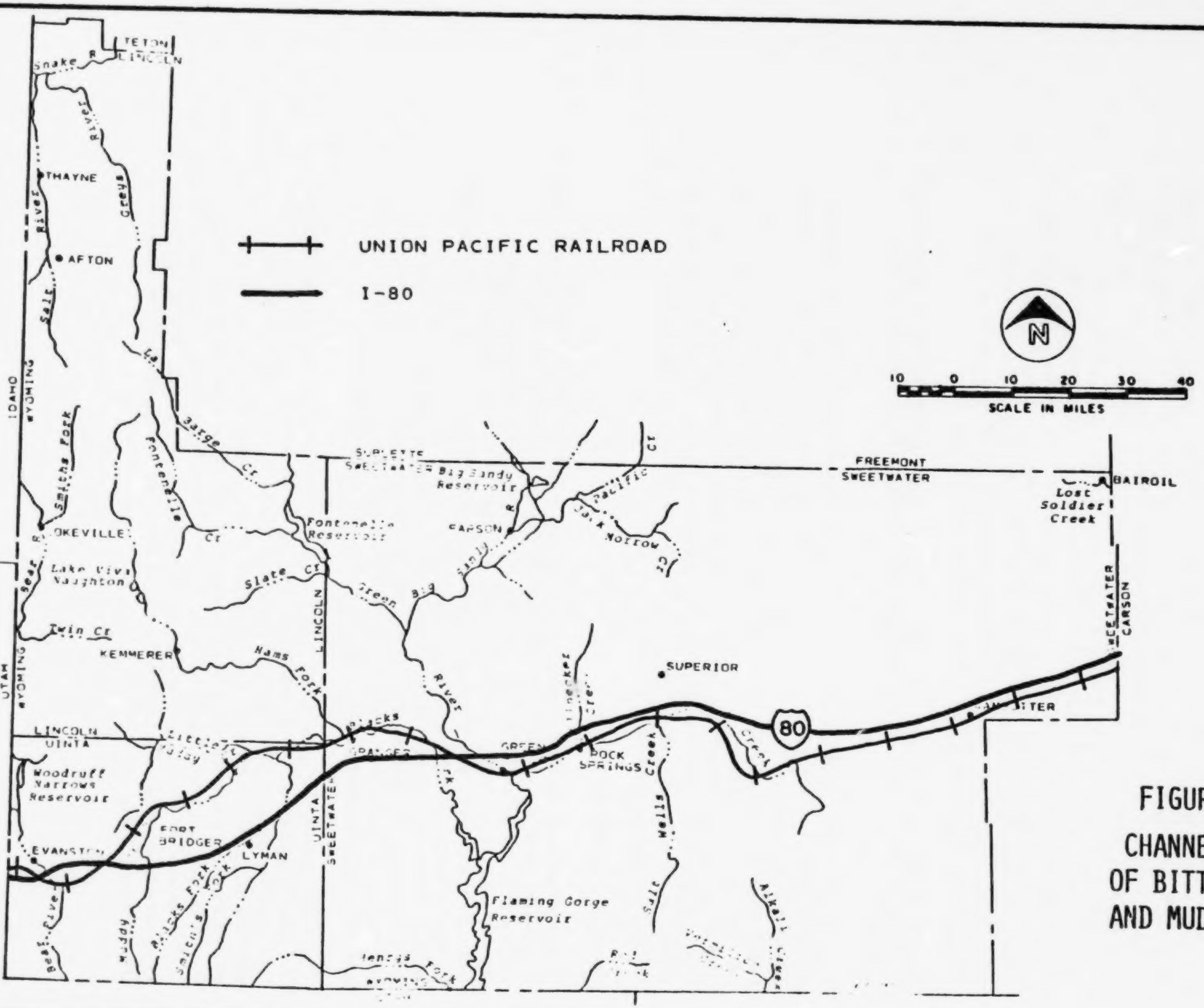
UNION PACIFIC RAILROAD
I-80
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Salt River
Greys River
IDAHO
WYOMING
La Barge Cr
Smiths Fork
Fontenelle Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
Pacific Cr
Jack Morrow Cr
CARSON
Big Sandy R
Fontenelle Reservoir
OKEVILLE
Bear R
Lake Viva Naughton
Slate Cr
Green River
Twin Cr
KEMMERER
Hams Fork
LINCOLN
UTAH
WYOMING
SUPERIOR
SWEETWATER
CARSON
80
Bitter Creek
LINCOLN
UINTA
Little Muddy
Blacks
GRANGER
GREEN
ROCK SPRINGS
Killpecker Cr
Woodruff Narrows Reservoir
FORT BRIDGER
LYMAN
UINTA
SWEETWATER
EVANSTON
Bear River
Muddy
Blacks Fork
Smiths Fork
Flaming Gorge Reservoir
Salt Wells Creek
Alkali Creek
Henrys Fork
WYOMING
UTAH

FIGURE 5-15

CHANNELIZATION
OF BITTER CREEK
AND MUDDY CREEK

CH2M HILL

Manure Runoff

Animals directly influence phosphorus loads in the rivers in the study area in two ways. First, as dicussed earlier, overgrazing can accelerate erosion of phosphorus-bearing soils. Second, manure can be washed into stream courses by snowmelt and storm water runoff.

The portion of the Green River Basin in the study area contains approximately 200,000 cattle and sheep, 60 percent of which are assumed to be in the Blacks Fork watershed and 40 percent in the Green River watershed. Phosphorus production by cattle was estimated at 35 pounds per head per year in a report done for the Teton County 208 Project, and 5 percent of the phosphorus in the manure was assumed in that report to be delivered to the streams by runoff. This delivery rate falls in the range of runoff losses from manure spread on frozen ground and is probably too high during periods when the ground is not frozen. Therefore a delivery rate of 2 percent was assumed in the study area. Given this delivery rate and phosphorus production rate, the estimated phosphorus loading from manure runoff to Flaming Gorge Reservoir is 65 tons per year. Forty tons are delivered to the reservoir by Blacks Fork and 25 tons by the Green River.

Manure runoff may also have some effect on fecal coliform and dissolved oxygen concentrations in the streams. The major water quality problems for both constituents shown on Figures 5-7 and 5-8 appear to be located more with respect to municipal treatment plants than to concentrations of livestock. However, some of the minor fecal coliform problems shown on Figure 5-7 are located in areas of heavy grazing, such as Bridger Valley and Lower Big Sandy River. Manure runoff may be a significant source in these areas.

The reason that manure runoff seems to be a minor contributor in most areas is that fecal coliform and oxygen demanding material are transported to the streams from manure during periods of runoff, or relatively high flow. Most of the samples have been taken during dry (non-runoff) periods, so water quality data may be inadequate to judge the full impact of manure runoff on stream quality. A second possibility is that during runoff periods these loadings might be diluted down to acceptable levels.

Urban Runoff

Major urban areas cover about 20 square miles of the approximately 15,000 square mile Flaming Gorge watershed. Even at a relatively high phosphorus loading rate of one pound per acre per year in urban runoff, the urban areas are estimated to contribute only six tons of phosphorus per year to Flaming Gorge Reservoir. Five of those 6 tons come from the Rock Springs-Green River area, while the remainder comes from the Kemmerer area and Bridger Valley. Loadings of salinity, fecal coliform, and oxygen demanding substances from urban runoff are even less significant in terms of total contaminant loadings.

The most important impact of urban runoff on water quality is probably associated with the increase in runoff from urbanized areas. As mentioned earlier, this flow increase will force a new channel geometry, thereby producing vertical erosion and bank sloughing. This process is clearly visible along Killpecker Creek. The impact of this process on contaminant loadings is difficult to assess quantitatively, however.

Septic Tanks

Most of the population in the study area is on municipal systems with discharges monitored under the NPDES program. However, approximately 2,000 people in the Blacks Fork watershed and 2,300 people in that part of the Green River watershed in the study area and tributary to Flaming Gorge Reservoir are on systems with no surface discharges. These systems are either septic tanks or nondischarging lagoons. Almost half of the total population on these systems is located in the Rock Springs-Green River area.

The estimated phosphorus loading discharged to these systems is 3.0 tons per year in the Green River watershed and 2.4 tons per year in the Blacks Fork watershed. With proper soil conditions and design, no phosphorus should be delivered from these systems to the surface waters. All the phosphorus should be sorbed to solid particles before the leachate or seepage reaches the streams. In reality, some of the systems in the study area are failing because of improper installation, overloading and poor soil conditions. Therefore, it is assumed that up to 50 percent of the phosphorus discharged to the systems may eventually reach the streams. Given this assumption, phosphorus loadings from septic tanks and nondischarging lagoons to streams may be as high as 1.5 tons per year in the Green River watershed and 1.2 tons per year in the Blacks Fork watershed.

More important than loadings of phosphorus are the loadings of fecal coliform and other bacteria and viruses from improperly operating septic tank systems. The majority of the fecal coliform problems from septic tanks has occurred in the Bridger Valley. Several cases of hepatitis in this area have been attributed to bacterial contamination of drinking water supplies from failing septic tanks. Reasons for the failing septic tanks are improper installation, high water tables primarily due to irrigation, poor soils, close proximity of septic tanks to wells, and poor maintenance.

Irrigation Return Flows

The greatest impact of agriculture on water quality in the study area is increasing salt loads carried by rivers. The mechanism is irrigation return flows. Irrigated areas are shown on Figure 5-16. Large areas of irrigation are located along the Bear River and the Salt River. In the Green River Basin, the largest areas of irrigation are located near Lyman on the Blacks Fork and the Smiths Fork, near Eden and Farson on the Big Sandy River, and in the Henrys Fork area. Irrigated lands cover 244,000 acres in the study area. This acreage includes irrigated lands, occasionally irrigated lands, and subirrigated lands.

An estimate was made of the salt loading from irrigation return flows in the Bridger Valley on the Blacks Fork and Smiths Fork. It was assumed that 4 feet of water are applied to the land during an irrigation season and

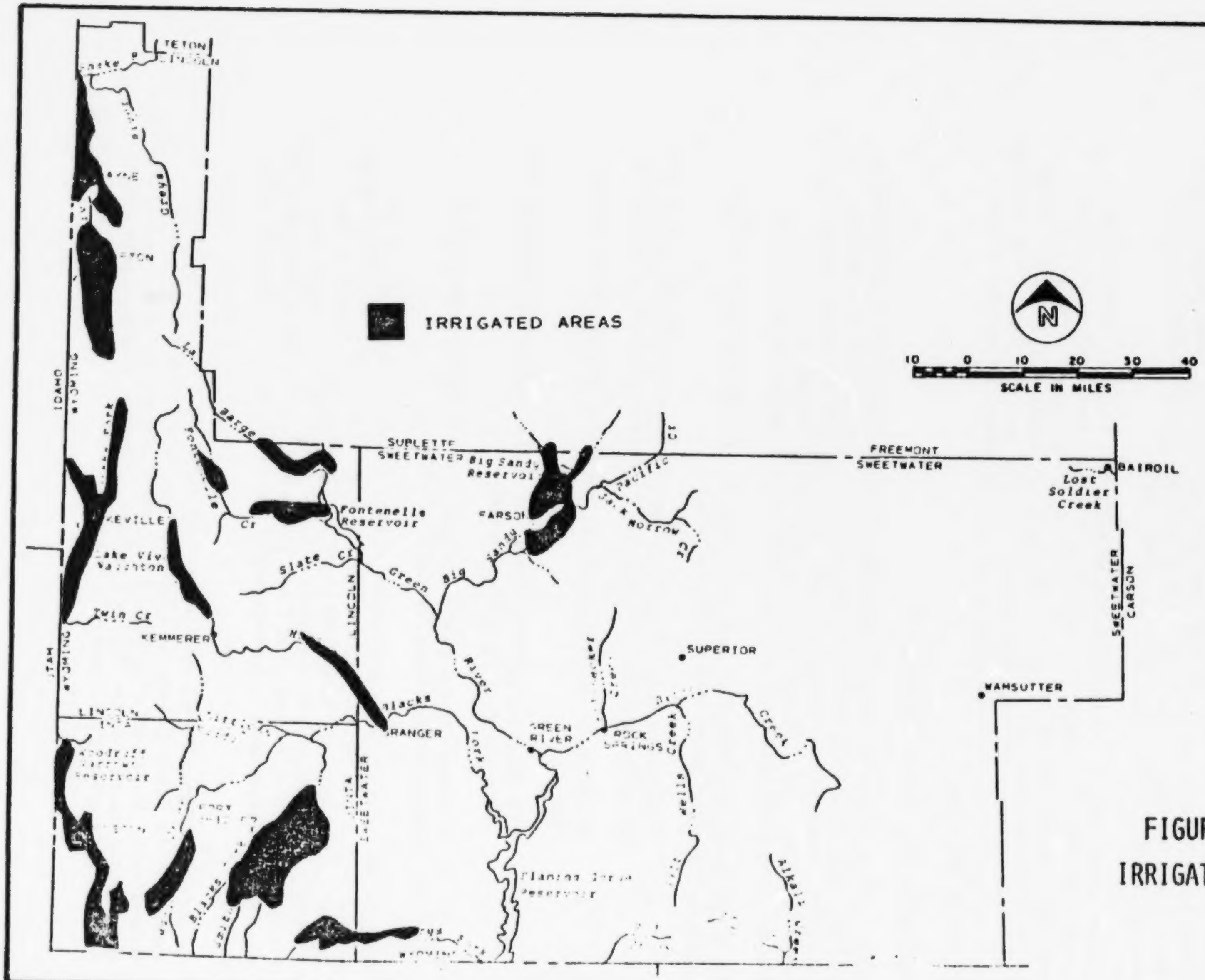
IRRIGATED AREAS
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
IDAHO
WYOMING
UTAH
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
LINCOLN
UINTA
SWEETWATER
SWEETWATER
CARSON
Big Sandy Reservoir
Fontenelle Reservoir
Flaming Gorge Reservoir
FARSON
KEMMERER
GRANGER
GREEN RIVER
ROCK SPRINGS
SUPERIOR
WAMSUTTER
BAIROIL
Lost Soldier Creek
Green River
Big Sandy
Pacific Cr
Jack Morrow Cr
Slate Cr
Twin Cr
Blacks Fork
Bitter Creek
Killpecker Creek
Alkali Creek
Salt River
Greys River
La Barge
Fontenelle Cr
KEVILLE
Cokeville
Snake

FIGURE 5-16
IRRIGATED AREAS

that the excess irrigation water returns to the Blacks Fork at the average concentration of the shallow ground water in the Blacks Fork area. This average, calculated from data on eight wells, was 654 mg/l of total dissolved solids. Given these assumptions, the salt load from irrigation return flow in this area is 125,000 tons per year, or 2.0 tons per acre per year. The loading rate is comparable to the rate of 2.4 tons per acre per year calculated by EPA for this area (EPA, 1971).

Ground water quality information was insufficient for other areas in the Green River Basin to make salt loading estimates. Salt loading estimates from the literature are given for the other major irrigated areas in the Green River Basin on Table 5-10. The total salt loading in the Green River Basin generated within the study area is 760,000 tons per year. The loadings from irrigation return flows account for approximately 37 percent of the total load generated.

Natural Ground Water Discharge

Salinity and phosphorus loads from ground water discharge to surface water are the most difficult contaminant sources in the study area to quantify. However, enough information is known about the ground water system to allow identification of the critical areas of ground water impact on surface water. These critical areas are identified in this section of the report.

In order for ground water to pick up significant amounts of salts or phosphorus, three conditions should be present:

- The consolidated or unconsolidated material through which the ground water passes must have leachable salts or phosphorus
- A source of recharge must be present to provide water to the system
- The geologic structure must facilitate deep circulation and then resurfacing of the ground water

The presence of these three conditions in any area indicates an area of significant ground water impact on surface water.

Regions in the study area with rocks of high leachability are shown on Figure 5-17. One region includes the Mancos-type shales, whose potential for delivering high salt loads has been identified in other areas of the Colorado River Basin. In the study area, these shales are called the Frontier, Hilliard, Baxter, and Cody Formations. Because of their marine origin, the shales have large amounts of leachable sodium, chlorine, and sulfate.

As shown on Figure 5-17, the largest regions of Mancos-type shales are located in the Bitter Creek, Salt Wells Creek, and Little Muddy Creek watersheds. Movement of ground water along contact zones with these shales is probably the reason for the high sulfate, chloride, and total dissolved loads in Killpecker Creek and Bitter Creek.

Table 5-10

SALT LOADING ESTIMATES FROM IRRIGATION RETURN FLOWS

Area	Annual Salt Loadings (tons)	Loading Rate (tons/ac/yr)	Reference
Blacks Fork and Smiths Fork	125,000	2.0	This study
		2.4	EPA (1)
Big Sandy River	≤277,000	≤14.6	SCS (2)
	140,000	7.4	SCS (3)
	73,000	3.9	EPA (1)
Hams Fork	17,000	1.5	EPA (1)
Henrys Fork	88,000	4.9	EPA (1)
TOTAL	303,000-507,000		

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(1) Environmental Protection Agency. 1971. *The mineral quality problems in the Colorado River Basin, summary report.*

(2) Soil Conservation Service. August 1976. *USDA plan of study for the Big Sandy unit, draft.*

(3) Soil Conservation Service. May 1975. *Plan of study for USDA participation in salinity control investigations for the Big Sandy River unit, Wyoming, draft.*

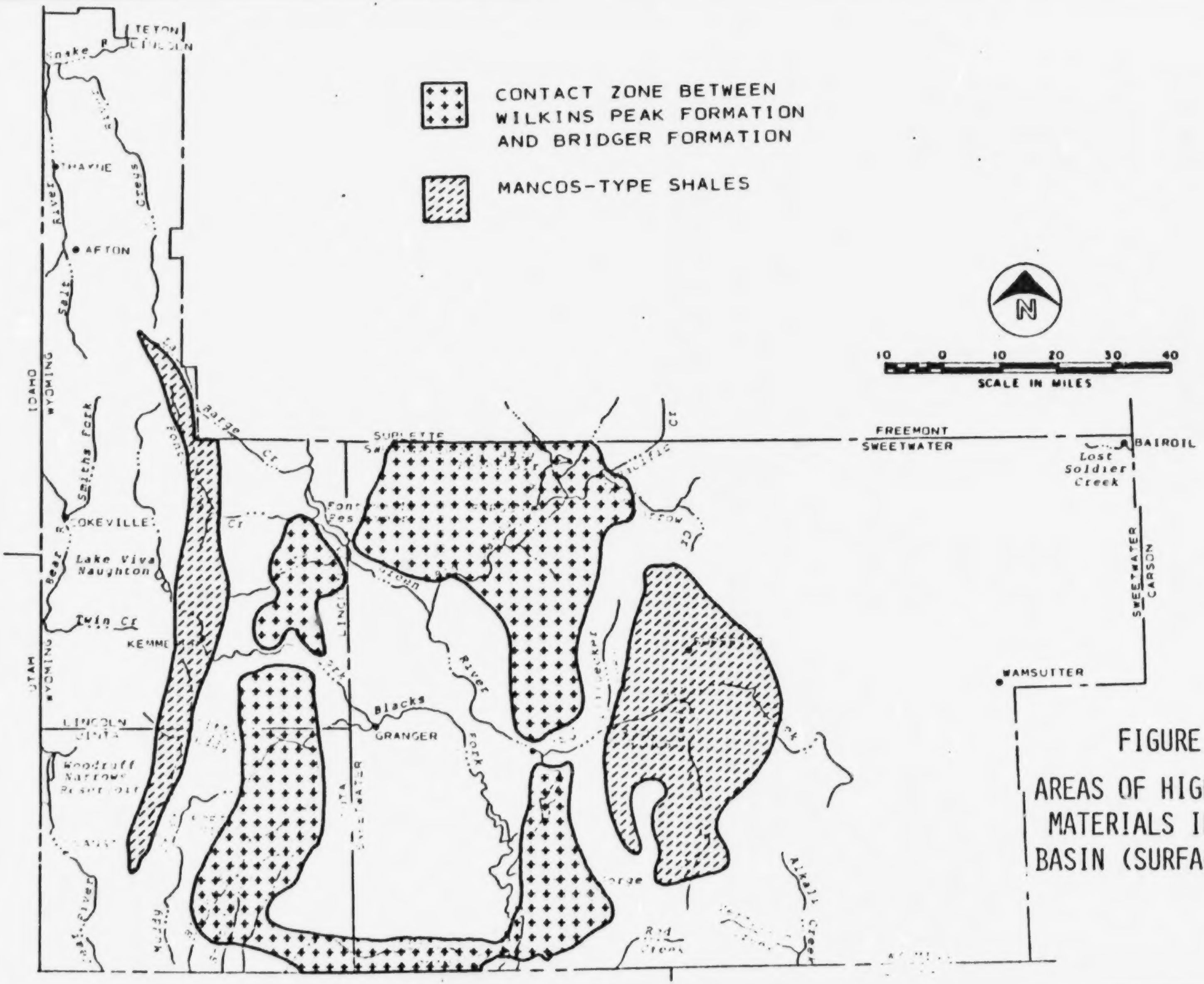
▦ CONTACT ZONE BETWEEN WILKINS PEAK FORMATION AND BRIDGER FORMATION
▨ MANCOS-TYPE SHALES
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Salt
River
Greys
IDAHO
WYOMING
UTAH
WYOMING
Smiths Fork
COKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMERER
LINCOLN
UINTA
Woodruff Narrows Reservoir
Barge Cr
Cr
Fontenelle Res
SUBLETTE
SWEETWATER
LINCOLN
UINTA
SWEETWATER
Blacks
GRANGER
Fork
River
Green
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
Alkali Creek
Red Creek
Gorge

FIGURE 5-17

AREAS OF HIGHLY LEACHABLE MATERIALS IN GREEN RIVER BASIN (SURFACE GEOLOGY MAP)

CH2M HILL

A second critical region is the contact zone between the Wilkins Peak Formation and the Bridger Formation. The Wilkins Peak Formation is particularly high in leachable sodium and carbonates and contains the trona patch presently being mined near Green River. The Bridger Formation is concentrated in calcium and sulfate. Calcium sulfate has a lower solubility than the sodium salts, and, therefore, the Bridger Formation is generally not as highly leachable as the Wilkins Peak Formation or the Mancos-type shales.

The leachability of the Bridger Formation is greatly increased along the contact zone between that formation and the Wilkins Peak Formation. In most parts of the study area, interaction between the two formations is prevented by a layer of impermeable Laney shale located between the two formations. However, along the contact zone, where the Laney shale is extremely thin or nonexistent, salts from the two formations interact in the following manner: sodium and bicarbonate from the Wilkins Peak Formation react with calcium and sulfate from the Bridger Formation to yield a precipitate of calcium carbonate along with dissolved sodium and sulfate. This interaction has two serious impacts. First, the chemical reaction pumps highly soluble sodium sulfate into the ground water system, which can create SAR problems in irrigation water and laxative problems in drinking water. Second, the calcium carbonate precipitate increases the permeability of the rock and permits a larger quantity of highly saline water to pass through the rock and into the surface water.

Water must be available to move through the rocks mentioned above in order to produce large salt loads in the ground water. In many areas there is little water available to recharge ground water. One such area is the trona patch, which is filled with trona (sodium sesquicarbonate) which has not been leached out because of the absence of perennial streams or sufficient precipitation to recharge the ground water.

The most important recharge areas in the study area occur along the perennial streams. Although most of the flow in these streams remains in the stream channels, some flow seeps through the banks and recharges the ground water system. Recharge in the study area has been increased by the construction of upstream reservoirs and by irrigation. These two activities convert some of the flow which used to continue downstream in the rivers to seepage and ground water recharge.

Four river sections have been identified to be in a region of highly leachable rock and soils and in a region of adequate recharge. These are two of the three conditions mentioned earlier for producing large salt loads in ground water. The four sections are--

- Big Sandy River between Big Sandy Reservoir and the confluence with the Green River
- Hams Fork between Kemmerer and Granger
- Blacks Fork and Smiths Fork between Robertson and Granger

- Henrys Fork between Burnt Fork and Manila.

A geologic structure that facilitates ground water movement is the third critical element needed to produce large salinity loadings. This type of structure is found in only two of the four river sections--the Big Sandy River and the Blacks Fork-Smiths Fork sections. As shown on Figure 5-4 and 5-5, large salinity loads are generated in the Big Sandy River section and the Blacks Fork-Smiths Fork section. Sodium and sulfate are the major contributors to the increase in total dissolved solids in these two sections. In the Big Sandy, the two reservoirs and the irrigation project are located at the upgradient end of the syncline and along the contact zone of the Bridger and Wilkins Peak Formations. Saline seeps are located at the downgradient end of the syncline. The syncline permits a deep circulation of the ground water (up to 300 feet) and a long contact time with the salinity-producing rocks. A similar situation occurs in Bridger Valley.

Structure in the Big Sandy area not only facilitates deeper circulation of ground water in the shallow aquifers, but also appears to allow very little of the highly saline water in the deep aquifers to reach the surface. Ground water in the deep aquifers would have to be forced through undeformed oil shale (Laney Formation) in order to reach the surface. Although this deep ground water is under a large head which has produced artesian conditions in wells in the area, large volumes of water probably do not pass through the oil shale because of its low permeability. A preliminary SCS water budget for the area, which will be refined in their final study on the Big Sandy unit of the Colorado River Salinity Project, substantiates the conclusion that no large volumes of water are delivered from the deep aquifers to the Big Sandy River. A rough water budget for the Bridger Valley area done by SWWQPA for this study indicates that, as in the Big Sandy area, an insignificant amount of salinity in the Blacks Fork stretch can be attributed to movement of ground water in the deep aquifers to the surface.

Structure appears to impede deep circulation of ground water in the shallow aquifers and movement of the ground water in the deep aquifer to the surface in the Henrys Fork and Hams Fork stretches. In Henrys Fork, high concentrations of calcium sulfate are present from leaching of the Bridger Formation. However, structure apparently does not facilitate circulation through the contact zone in the Henrys Fork watershed, because large loadings of sodium sulfate are not present in the river. A similar situation occurs in the Hams Fork. The upper sections of this river and Viva Naughton Reservoir are located in a geologic overthrust belt, and recharge from this area may move downwards into deep ground water aquifers which do not impact surface waters in the Hams Fork.

The discussion above indicates that most of the salinity loadings from natural ground water discharges come from the shallow aquifers in the Big Sandy drainage and Bridger Valley, and not from either the deep aquifers in those two stretches or from shallow and deep aquifers in the Henrys Fork and Hams Fork stretches. Salinity loadings from ground water have been calculated by subtracting the loadings calculated earlier for irrigation return flows and erosion from the salinity loads in the river. These differences are shown for the Green River, Blacks Fork, and Henrys Fork on Table 5-11.

Phosphorus loads in ground water result from the same three conditions which produce large salinity loads in ground water. The Permian Phosphoria Formation contains a high content of phosphorus. Because of its age, the formation is often far below the surface and below the ground water systems affecting surface water in the study area. Figure 5-18 shows those areas where the formation is near enough to the surface to have a potential impact on surface water quality.

The largest phosphorus deposits and the greatest impact of them on surface water appear to be in the Bear River and Greys River watersheds. Water quality data indicate high phosphorus loads in the Bear River, particularly in the lower reaches; however, information is not available to define the importance of phosphorus in ground water to the total load in the river. Water quality data on phosphorus in the Greys River are scarce, so neither total loads nor the contribution of ground water can be determined.

Silviculture

Silviculture is not an important activity in the study area, because most of the area is not forested, and because those parts that are forested are not easily accessible or highly productive. Most of the forested land is also on State or Federal land, and there is a strong demand to maintain these public forests for wildlife habitat, recreation, and scenery. Therefore, silviculture is not considered to be an important existing contaminant source and is not expected to develop into one in the future.

Residual Wastes Disposal

No water quality problems could be associated with the disposal of residual wastes. Quality of the ground water is not monitored in the vicinity of the disposal sites, so it is not known whether problems from residual wastes disposal may arise in the future.

Oil Spills

Occasional oil spills have occurred in the Rock Springs area. The bottom deposits in Killpecker Creek are saturated with oil in the vicinity of the Wyoming Highway Department facilities, the Delgago Oil Company, and the Sage Construction Company. These oil deposits can add considerably to the BOD of waters in Killpecker Creek.

SUMMARY

Loading Budgets for Phosphorus

Table 5-12 presents the loading estimates from all phosphorus sources to the Green River arm and Blacks Fork arm of Flaming Gorge Reservoir. The values were derived from the empirical methods described earlier, rather than from actual data directly. The empirical data are more convenient to

Table 5-11

ESTIMATED SALINITY LOADINGS IN THE STUDY AREA FROM GROUND WATER

River	Salinity Loadings From Ground Water (1,000 tons/year)
Green River	141-345 (1)
Blacks Fork	181 (2)
Henrys Fork	19

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(1) Loading comes primarily from shallow aquifers in the Big Sandy River.
(2) Loading comes primarily from shallow aquifers in Bridger Valley.

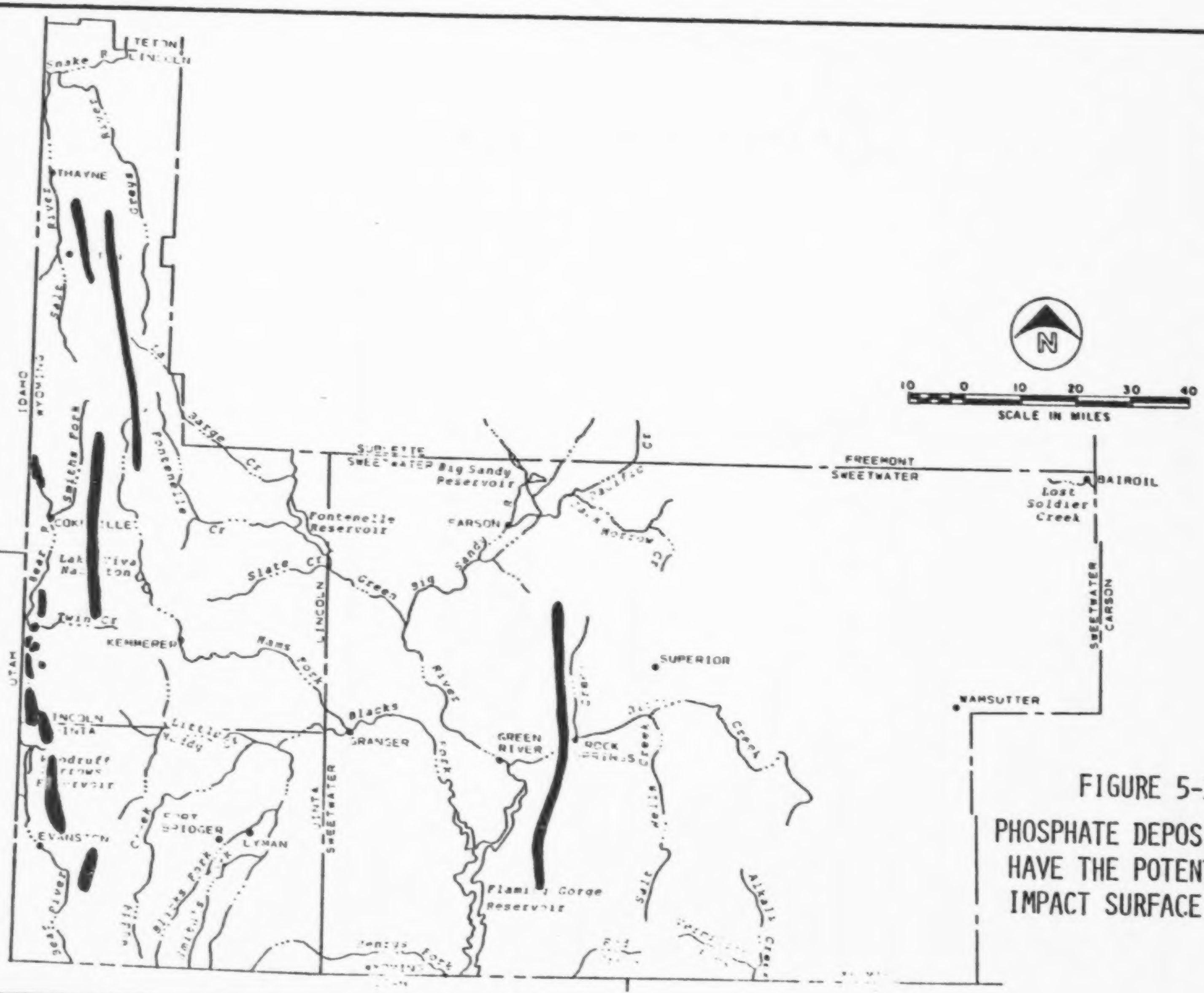
TETON
LINCOLN
Snake R
THAYNE
Greys
River
Salt
IDAHO
WYOMING
Smiths Fork
La Barge Cr
Fontenelle
Cr
COKEVILLE
Lake Viva Naughton
Bear
Twin Cr
KEMMERER
UTAH
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
Bear River
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Slate Cr
Green
Big Sandy
LINCOLN
Hams Fork
Little Muddy Cr
Blacks Fork
GRANGER
FORT BRIDGER
LYMAN
SWEETWATER
UINTA
River
GREEN RIVER
ROCK SPRINGS
SUPERIOR
Flaming Gorge Reservoir
Salt
Killpecker
Creek
Alkali Creek
Henrys Fork
Cr
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
N
10 0 10 20 30 40
SCALE IN MILES

FIGURE 5-18

PHOSPHATE DEPOSITS WHICH HAVE THE POTENTIAL TO IMPACT SURFACE WATERS

CH2M HILL

Table 5-12

PHOSPHORUS BUDGET FOR FLAMING GORGE RESERVOIR ARMS
(tons/year)

Source	To Green River Arm	To Blacks Fork Arm
POINT SOURCES		
Mining and Industrial Discharges	0	0
Municipal and Private Treated Sewage Discharges	54	12
Dairies and Feedlots	0	0
Stack Emissions	0	0
Springs	0	0
Nondischarging Wastewater Ponds	0	0
NONPOINT SOURCES		
Geologic Erosion	198-211	88-121
Overgrazing	29-42	74-107
Mining Site Erosion	0	0
Construction Site Erosion	(a)	(a)
Agricultural Runoff	0	0
Manure Runoff	25	40
Urban Runoff	5	1
Septic Tanks	2	1
Irrigation Return Flows	0	0
Natural Ground Water Discharges	0	0
Silviculture	0	0
Residual Wastes Disposal	0	0
Oil Spills	0	0
POINT LOADINGS	54	12
NONPOINT LOADINGS	272	232
TOTAL LOADINGS	326	249
1976 INSTREAM LOAD	295	80

(a) Unknown contribution from construction and channelization.

work with because they relate directly to the sources. Instream data, on the other hand, lump all sources together. Total empirical loadings are compared with actual instream data on Table 5-12. The agreement for the Green River Arm is satisfactory; the apparent disagreement in the Blacks Fork Arm has not been investigated, but is likely due to low flow or climatic differences for the year for which specific instream data are shown. Because phosphorus loadings are highly dependent on erosion, and therefore precipitation patterns, wide variations instream are likely. The empirical values tend to average out these variations.

As shown on Table 5-12, the four principal phosphorus sources to the two arms of Flaming Gorge Reservoir are municipal wastewater discharges, geologic erosion, overgrazing, and manure runoff. The facilities and reaches delivering most of the phosphorus from these four sources are listed on Table 5-13. Management options will be developed in Chapter 9 to control these sources.

Estimated phosphorus loadings to the main body of Flaming Gorge Reservoir are presented on Table 5-14. The Green River Arm and Blacks Fork Arm serve as natural phosphorus treatment basins for the main body of the reservoir. Phosphorus is reduced in the two arms by sedimentation of particulate phosphorus and by algal uptake and settling. Phosphorus loadings from the two arms to the main body of the reservoir have been estimated from total phosphorus concentrations in the arms and flows at Green River near Green River and Blacks Fork near Little America. Only 31 percent of the 326 tons per year delivered to the Green River Arm and 8 percent of the 249 tons per year delivered to the Blacks Fork Arm are estimated to reach the main body of the reservoir. Because of the natural processes occurring in the two arms, the estimated phosphorus loading reaching the main body of the reservoir is less than the estimated phosphorus loadings reaching either of the two arms.

The loadings from the two arms to the main body of the reservoir are based on limited water quality data. More work on these loading estimates should be done as more phosphorus data in the two arms become available.

Loading Budget for Salinity

A loading budget for salinity in the Green River Basin is presented on Table 5-15. Empirical estimates have been made of the salinity delivered in irrigation return flows and from erosion. The salt loadings in ground water are the difference between the measured instream loads and the empirically derived loadings from irrigation return flows and erosion. As shown on the table, most of the salt loading comes from natural ground water discharge to the surface waters. Irrigation return flows account for an estimated 35 to 58 percent of the salts generated in the study area. The salt contribution from erosion is negligible.

The sources and locations of salinity problems are summarized on Table 5-16. All the salinity problems result in part, and in some cases totally, from natural ground water discharges. Management options will be developed in Chapter 8 to control the salinity sources listed on the table.

Table 5-13

PRINCIPAL EXISTING PHOSPHORUS SOURCES

Municipal Wastewater Discharges	Rock Springs Green River Kemmerer-Diamondville Granger Fort Bridger Lyman Mountain View
Geologic Erosion (from Figure 5-12)	Lower Muddy Creek Reach Little Muddy Creek Reach Church Butte-Blacks Fork Reach Killpecker Creek Jack Morrow Creek
Overgrazing (from Table 5-9)	Lower Muddy Creek Reach Little Muddy Creek Reach Church Butte-Blacks Fork Reach Killpecker Creek Upper Bitter Creek Reach Salt Wells Creek Lower Big Sandy River Reach
Manure Runoff	Same as those for overgrazing

Table 5-14

PHOSPHORUS BUDGET FOR THE MAIN BODY OF FLAMING GORGE RESERVOIR (tons/year)

Source	Loading
POINT SOURCES (1)	
All Sources	0
NONPOINT SOURCES (1)	
Geologic Erosion and Overgrazing	75
All Others	0
OTHER SOURCES	
Flow from Green River Arm	100
Flow from Blacks Fork Arm	20
TOTAL	195

---

(1) Sources which contribute phosphorus to Green River arm or Blacks Fork arm are not included. They are indirectly addressed under the category "Other Sources".

Table 5-15

SALINITY BUDGET FOR GREEN RIVER IN WYOMING

Source	Green River	Blacks Fork	Henrys Fork
ALL SOURCES OUTSIDE STUDY AREA	300	0	0
POINT SOURCES			
All Sources	0	0	0
NONPOINT SOURCES			
Geologic Erosion	10	4	3
Overgrazing	2	3	0
Mining Site Erosion	0	0	0
Construction Site Erosion	0	0	0
Agricultural Runoff	0	0	0
Manure Runoff	0	0	0
Urban Runoff	0	0	0
Septic Tanks	0	0	0
Irrigation Return Flows	73-277	142	88
Natural Ground Water Discharges	141-345	181	19
Silviculture	0	0	0
Residual Wastes Disposal	0	0	0
Oil Spills	0	0	0

TOTAL EROSION	22	(3%)
TOTAL IRRIGATION RETURN FLOWS	303-507	(35-58%)
TOTAL NATURAL GROUND WATER DISCHARGES	341-545	(39-62%)
TOTAL	870	(100%)

Table 5-16

PRINCIPAL EXISTING SALINITY SOURCES

Use	Constituent	Reach with Water Quality Problem	Source	Location
Industrial Water Supply	Total Dissolved Solids	Green River, Big Island Reach to Green River Arm	Irrigation return flows	Contact zone, Big Sandy drainage
			Natural ground water discharges	Contact zone, Big Sandy drainage
			Outside study area	Sublette County
		Blacks Fork Arm	Irrigation return flows	Contact zone, Bridger Valley
			Natural ground water discharges	Contact zone, Bridger Valley
		Middle Hams Fork	Natural ground water discharges	Bridger formation, Hams Fork drainage
Livestock and Wildlife Watering	Chloride	Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage
	Sulfate	Upper Bitter Creek	Natural ground water discharges	Mancos-type shales, Bitter Creek drainage
		Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage
	Total Dissolved Solids	Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage
Public Water Supply	Sulfate	Green River	Irrigation return flows	Contact zone, Big Sandy drainage
			Natural ground water discharges	Contact zone, Big Sandy drainage
		Flaming Gorge Reservoir	Irrigation return flows	Contact zone, Big Sandy drainage and Bridger Valley
			Natural ground water discharges	Contact zone, Big Sandy drainage and Bridger Valley
		Lyman Reach-Blacks Fork	Irrigation return flows	Contact zone, Bridger Valley
			Natural ground water discharges	Contact zone, Bridger Valley
		Lower Hams Fork	Natural ground water discharges	Bridger formation, Hams Fork drainage
	Total Dissolved Solids	Green River	Irrigation return flows	Contact zone, Big Sandy drainage
			Natural ground water discharges	Contact zone, Big Sandy drainage
			Outside study area	Sublette County

Loadings of Other Contaminants

The sources and locations of fecal coliform and dissolved oxygen problems are summarized on Table 5-17. Sources of these contaminants are numerous and vary from location to location. In general, however, municipal wastewater discharges appear to be the most important contaminant sources, with septic tanks also important in the Bridger Valley. Management options will be developed in Chapter 10 to control the sources listed on the table.

Table 5-17

OTHER PRINCIPAL CONTAMINANT SOURCES

Use	Constituent	Reach with Water Quality Problem	Source	Location
Secondary Contact Recrea- Recreation	Fecal Coliform	Lower Green River	Municipal wastewater discharges	Rock Springs Green River
		Bitter Creek	Municipal wastewater discharges	Rock Springs South Superior Husky Truck Stop
		Salt Wells Creek	Manure runoff	Salt Wells Creek drainage
		Killpecker Creek	Manure runoff	Killpecker Creek drainage
			Septic tanks	Killpecker Creek drainage
		Lower Smiths Fork	Municipal wastewater discharges	Mountain View
			Manure runoff	Bridger Valley
			Septic tanks	Bridger Valley
		Middle Hams Fork	Municipal wastewater discharges	Kemmerer-Diamondville
Primary Contact Recreation	Fecal Coliform	Border Reach, Bear River[1]	?	?
		Green River (#13, #15, #16, #17)	Manure runoff	Green River drainage
		Lower Green River (#18)	Municipal wastewater discharges	Rock Springs Green River
		Upper Big Sandy[1]	Manure runoff	Big Sandy drainage
		Blacks Fork, Lyman to Little America[1]	Municipal wastewater discharges	Kemmerer-Diamondville Granger Lyman Mountain View
			Manure runoff	Bridger Valley
			Septic tanks	Bridger Valley
		Middle Hams Fork[1]	Municipal wastewater discharges	Kemmerer-Diamondville
Fishery	Dissolved Oxygen	Snake River	Municipal wastewater discharges (BOD_5)	Outside study area
			Principal phosphorus sources	Outside study area
		Green River, Lower Reach	Municipal wastewater discharges (BOD_5)	Green River Husky Truck Stop South Superior
			Principal phosphorus sources	See Table 5-13
		Hams Fork, Middle and Lower	Municipal wastewater discharges (BOD_5)	Kemmerer-Diamondville
			Municipal wastewater discharges (phosphorus)	Kemmerer-Diamondville

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(1) Under national goal only.

Chapter 6
FUTURE WATER QUALITY

Rock Springs, Green River, and Kemmerer have the atmosphere of boom towns. And yet the boom may have just begun. Vast deposits of trona, coal, uranium, and oil shale, and vast reserves of oil and natural gas are still to be developed. The development of these resources may cause water quality problems more severe than those already impacting the study area.

The information on existing water quality given in Chapter 3 and on contaminant sources in Chapter 5 can be used to predict future water quality. This information is applied to scenarios of future conditions developed in this chapter to estimate the degree to which contaminant loadings and concentrations may change in the future.

IMPACTS OF ENERGY DEVELOPMENT

In Chapter 5 both man-caused and natural sources of pollution were discussed. Projections of future water quality in this chapter are only made in terms of man-caused sources. Pollutant loadings from natural sources vary considerably from year to year because of the large changes in the amounts and intensities of precipitation. For example, during a year characterized by a large number of intense thunderstorms, geologic erosion will be relatively high and streams will carry relatively large loads of phosphorus. In contrast, during a dry year the pollution loadings from such natural sources will be low. It has been assumed here that these weather effects would balance out and that there will be no increase or decrease in pollutant loadings from natural sources over the next 20 to 40 years.

On the other hand, pollutant loadings from man-induced sources are likely to change considerably over the next 20 to 40 years. The study area contains vast, untapped mineral reserves. Information from the State Engineer's Office and from energy and mineral companies indicates that there will be a rapid development of these resources over the next 20 to 40 years. Existing and proposed mining sites and developed oil and gas fields are located on Figure 6-1 (Department of Economic Planning and Development, 1977). As shown on the figure, the future development of resources will be particularly intense in Sweetwater County. Rock Springs, already with the atmosphere and appearance of a boom town, should continue to grow at a rapid rate. Population growth from mineral resources development should also take place in the Town of Green River and the Kemmerer area.

Mineral resources development is likely to have strong impacts on future water quality without the institution of water quality management practices. These impacts will probably be secondary in nature. The conclusion in Chapter 5 was that almost all existing mineral resources development has had minimal direct or primary impact on surface water because it has generally taken place at great distances from surface waters, because all the

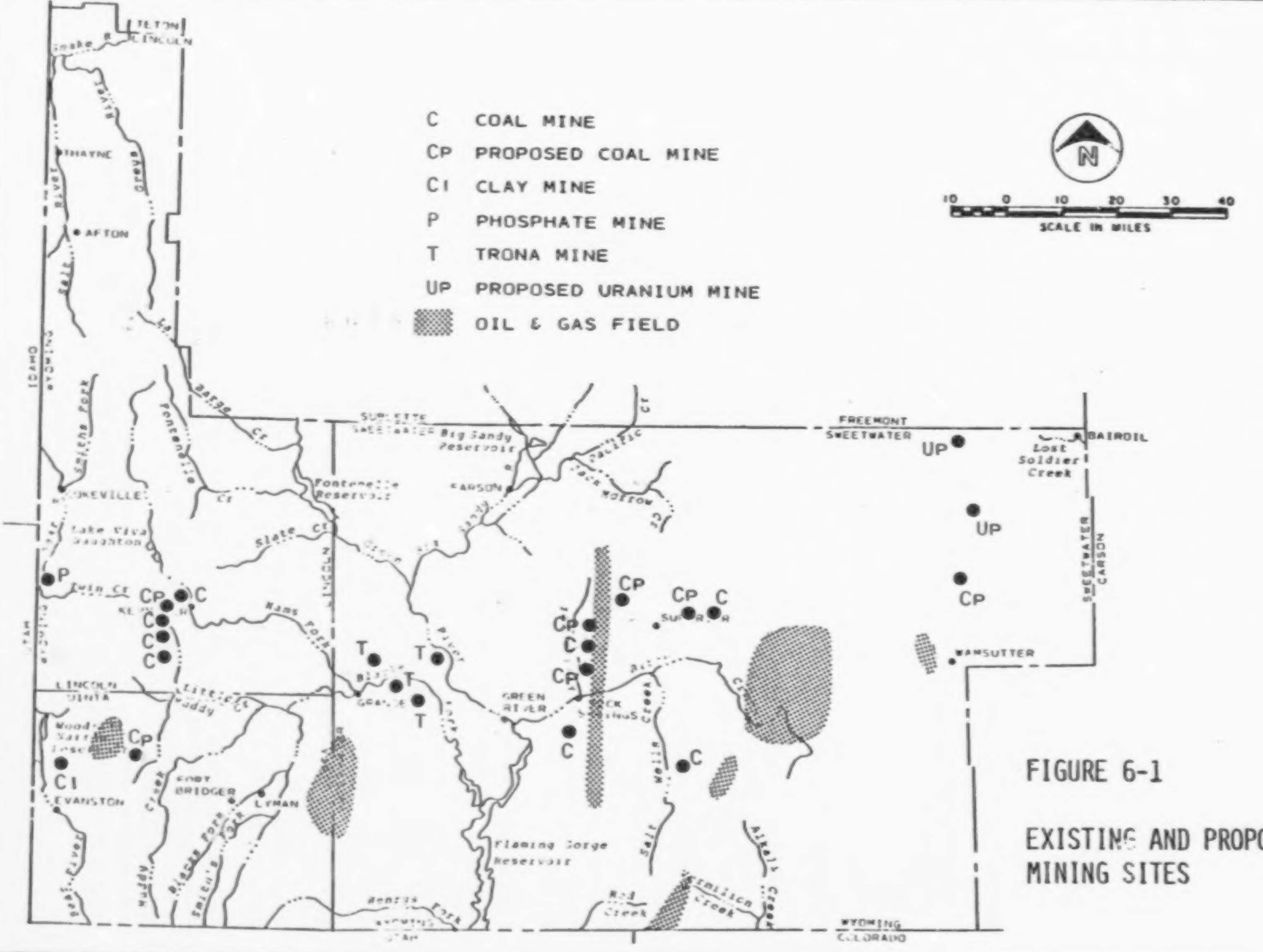
C COAL MINE
CP PROPOSED COAL MINE
CI CLAY MINE
P PHOSPHATE MINE
T TRONA MINE
UP PROPOSED URANIUM MINE
▨ OIL & GAS FIELD
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
IDAHO
WYOMING
Salt River
Greys River
La Barge Cr
Fontenelle Cr
COKEVILLE
Lake Viva Naughton
P
Twin Cr
KEMMERER
CP
C
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Slate Cr
Hams Fork
LINCOLN
UINTA
Muddy Cr
Little Muddy Cr
CI
EVANSTON
FORT BRIDGER
LYMAN
Blacks Fork
Smith's Fork
Bear River
UTAH
T
GRANGER
Green River
GREEN RIVER
ROCK SPRINGS
Flaming Gorge Reservoir
Henrys Fork
Pacific Cr
Jack Morrow Cr
SUPERIOR
Bitter Cr
Salt Wells Creek
Red Creek
Vermillion Creek
Alkali Creek
FREEMONT
SWEETWATER
UP
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
WYOMING
COLORADO

FIGURE 6-1

EXISTING AND PROPOSED MINING SITES

energy and mineral development industries are not discharging wastewater, and because development has not taken place in areas of recharge to those ground water aquifers which have an eventual impact on surface waters. One exception is coal mining along Hams Fork near Kemmerer.

Most future mineral resources development is shown on Figure 6-1 to continue in areas which are likely to have minimal direct impact on surface waters. Most of the proposed mine sites are out of the alluvial valleys and not in important areas of recharge to the ground water. The only area of proposed mine sites where direct impacts may occur is along Killpecker Creek. This area was identified in Chapter 3 to have high salinities and in Chapter 5 to have high unit phosphorus loading rates. Mineral development in this area should be monitored closely for potential water quality impacts.

Future secondary impacts of mineral resources development on water quality will probably outweigh the primary impacts. These secondary impacts include--

- Greater consumptive use of water, which may have the effect of concentrating contaminants remaining instream.
- Population growth, which will increase the discharge of pollutants from wastewater treatment plants unless treatment is upgraded.
- Construction of roads, homes, and businesses, which will increase erosion rates unless special construction practices are used.
- Channelization of streams to protect roads, railroads, homes, and businesses, which may have the effect of increasing the stream gradient, thereby increasing both the erosive capabilities of the streams and their capabilities to carry sediment loads to the major rivers and reservoirs.

The secondary impacts of energy and mineral development in the study area fall into three major categories: increased erosion, increased wastewater discharges from municipal treatment plants, and increased (or decreased) instream pollutant concentrations from new diversions and depletions. The pollutant loadings from increased erosion are difficult to quantify. Because of the importance of erosion to phosphorus loadings to Flaming Gorge Reservoir (see Chapter 5), increases in pollutant loadings from new man-induced erosion may be substantial for not only phosphorus but also other pollutants such as metals. The effects of the other two secondary impacts, increased wastewater discharges and increased diversions and depletions, have been quantified for the scenarios described in the following section.

FUTURE DEVELOPMENT SCENARIOS

Scenarios of the study area's potential growth have been developed to estimate what impact future developments will have on water quality. A scenario describes the kind and level of possible development and the associated socioeconomic characteristics. The basic data used in forming the scenarios included population and employment forecasts and local development plans. Information was gathered from industry and the three levels of government.

Purpose of Scenarios

The end objective of the scenarios was to provide water demand forecasts in order to establish a basis for determining potential water quality problems and for testing the effectiveness of possible control concepts, as discussed in a later chapter. It is not important that the scenarios be entirely accurate in terms of specific industries. Their purpose is to reflect the relationship of different levels of development to water quality. The scenarios have been generated to see if different development patterns produce significantly different water quality situations. Through the Green River computer model, the scenarios have been used to tell what level of development is associated with what degree of impact. Although they have been devised from the best data available, the scenarios are only estimates of future growth drawn from existing documents, not from original research.

Development of Population Scenarios

Two scenarios were prepared to represent different intensities of development in the study area, as implied by the wide range of population and employment projections in the various studies consulted. Both considered six major impact areas: (1) Green River, (2) Rock Springs, (3) Bridger Valley, (4) Evanston, (5) Kemmerer, and (6) a new town that would be built near Wamsutter.

The more aggressive scenario has been titled "Energy Export." It assumes that the resources of the study area will be converted locally and that the resulting energy will be shipped to outside areas. This scenario assumes (1) an exponential demand for energy in the U.S., (2) continued increases in international crude oil prices, (3) national policy for energy independence, (4) quantum technological advancements, and (5) sufficient water and labor supply. Given these assumptions, development of oil shale and coal gasification and accelerated electric power generation are possible. This scenario results in a population increase in the SWWQPA area from about 79,000 in 1985 to approximately 143,000 by the year 2000.

The less aggressive scenario has been titled "Coal Export." It projects that population in the SWWQPA study area will be about 73,000 in 1985 and 85,000 in the year 2000. The scenario is based on the export of coal from the study area to other areas for energy conversion. The assumptions used included (1) the people of Wyoming will decide against further development of power generating facilities that export energy to outside areas; (2) technology permitting the use of high sulfur eastern coal, oil shale, or coal gasification will be developed; (3) the national demand for energy will not expand as rapidly as projected in the early 1970's.

Population estimates resulting from the two levels of development are presented on Table 6-1. The actual level of development that does occur will depend not only on economic factors, but also on policy decisions made at the State or national level. The two scenarios that have been developed reflect both these influences on growth.

Table 6-1

POPULATION ESTIMATES

Energy Export Scenario

Impact Area	1975	1985	2000
Green River	9,000	20,270	33,670
Rock Springs	20,000	36,600	60,800
Bridger Valley	3,200	3,940	7,110
Evanston	4,900	5,470	9,860
Kemmerer	4,600	10,100	19,900
Wamsutter	-	2,550	11,290
TOTAL	41,700	78,930	142,630

Coal Export Scenario

Impact Area	1975	1985	2000
Green River	9,000	17,010	20,020
Rock Springs	20,000	31,590	36,205
Bridger Valley	3,200	4,170	4,388
Evanston	4,900	5,760	6,060
Kemmerer	4,600	10,600	11,700
Wamsutter	-	3,970	6,890
TOTAL	41,700	73,110	85,263

The employment multiplier used in the two scenarios is the same as that developed by the U.S. Bureau of Reclamation in its Sublette County study (USBR, Sept. 1976). It is obtained by assuming that 2.2 service jobs follow each additional basic job. The product of this calculation is then divided by 1.2, which is the average number of persons employed per household in the SWWQPA area, and then multiplied by the average household size, which is 3.4. Thus, for every 100 new basic employment positions, population will increase by 623, as calculated below:

$$100 \times 2.2 : 1.2 \times 3.4 = 623$$

This multiplier was applied to all basic employment except construction. A multiplier of 4.5 was assumed for this sector due to the smaller family sizes typically associated with construction workers. Using the same formula presented above, but reducing the average family size from 3.4 to 2.45 results in a construction multiplier of 4.5.

Water Demands

The projected water demands in the study area for both scenarios are given on Table 6-2. As is evident from this table, depletions due to agricultural demands and reservoir evaporation are not predicted to change under either scenario. However, industrial and municipal depletions increase significantly. The location and quantity of existing industrial depletions in the Green River Basin are shown on Figure 6-2, while the location and quantity of projected industrial depletions under the two scenarios are shown on Figures 6-3 and 6-4.

None of the water shown as depleted on the two figures is assumed to be returned to the streams. Under these scenarios, water is used consumptively within the basin. This assumption describes present practices within the Green River Basin.

Table 6-2

WATER DEPLETION ESTIMATES FOR THE STUDY AREA
(In acre-feet per year)

	1975	2000	
		Energy Export	Coal Export
Industrial	63,590	175,174	104,674
Agricultural	223,650	223,650	223,650
Municipal	4,170	14,270	8,715
Other (1)	9,310	23,300	23,300
Reservoir Evaporation	26,300	26,300	26,300
TOTAL	327,020	462,694	386,639

---

(1) The "Other" category includes water used for fish and wildlife and for livestock depletions.

The total depletions developed for the two scenarios and presented on Table 6-2 do not include transbasin diversions to points outside of the study area. The possibility exists that water available under the Colorado River compact will be diverted out of the study area to water-short regions in eastern Wyoming. The State of Wyoming has projected that by year 2000 about 92,000 acre-feet per year may be diverted from the Green River Basin to other basins within the State.

The points of any transbasin diversions are undetermined at the present time. Therefore, three different transbasin diversion scenarios have been developed to assess the impacts of transbasin diversions on the Green River Basin and Colorado River Basin:

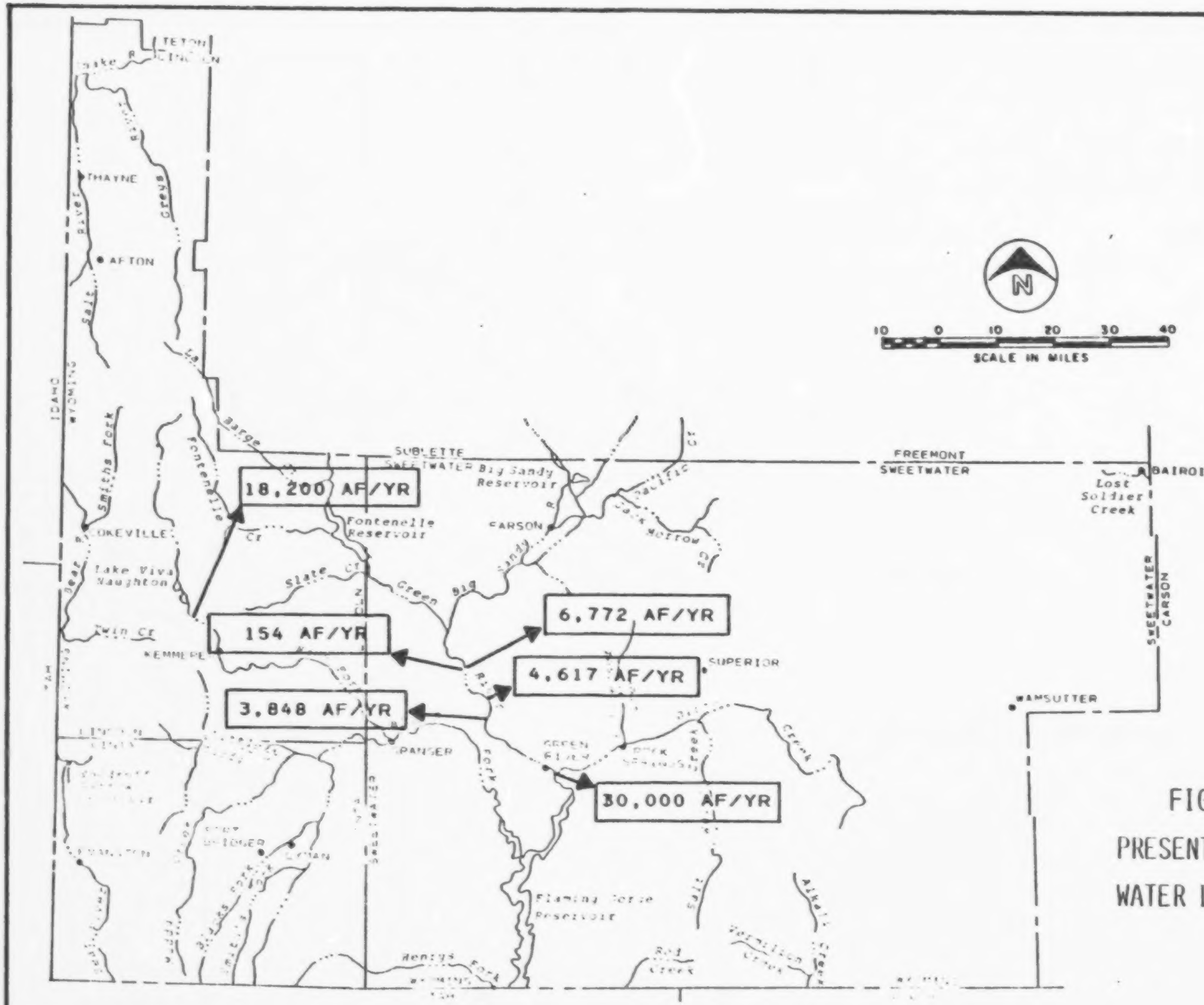
18,200 AF/YR
154 AF/YR
3,848 AF/YR
6,772 AF/YR
4,617 AF/YR
30,000 AF/YR
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Salt River
Greys River
La Barge
IDAHO
WYOMING
Smiths Fork
COKEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMERER
Fontenelle Cr
Fontenelle Reservoir
Slate Cr
Green River
Big Sandy R
Big Sandy Reservoir
FARSON
Pacific Cr
Jack Morrow Cr
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
SUPERIOR
WAMSUTTER
GREEN RIVER
ROCK SPRINGS
GRANGER
FORT BRIDGER
LYMAN
Blacks Fork
Hams Fork
Flaming Gorge Reservoir
Henrys Fork
Salt Wells Creek
Alkali Creek
Vermilion Creek
Red Creek
Bitter Creek
UTAH
WYOMING

FIGURE 6-2
PRESENT INDUSTRIAL
WATER DEPLETIONS

CH2M HILL

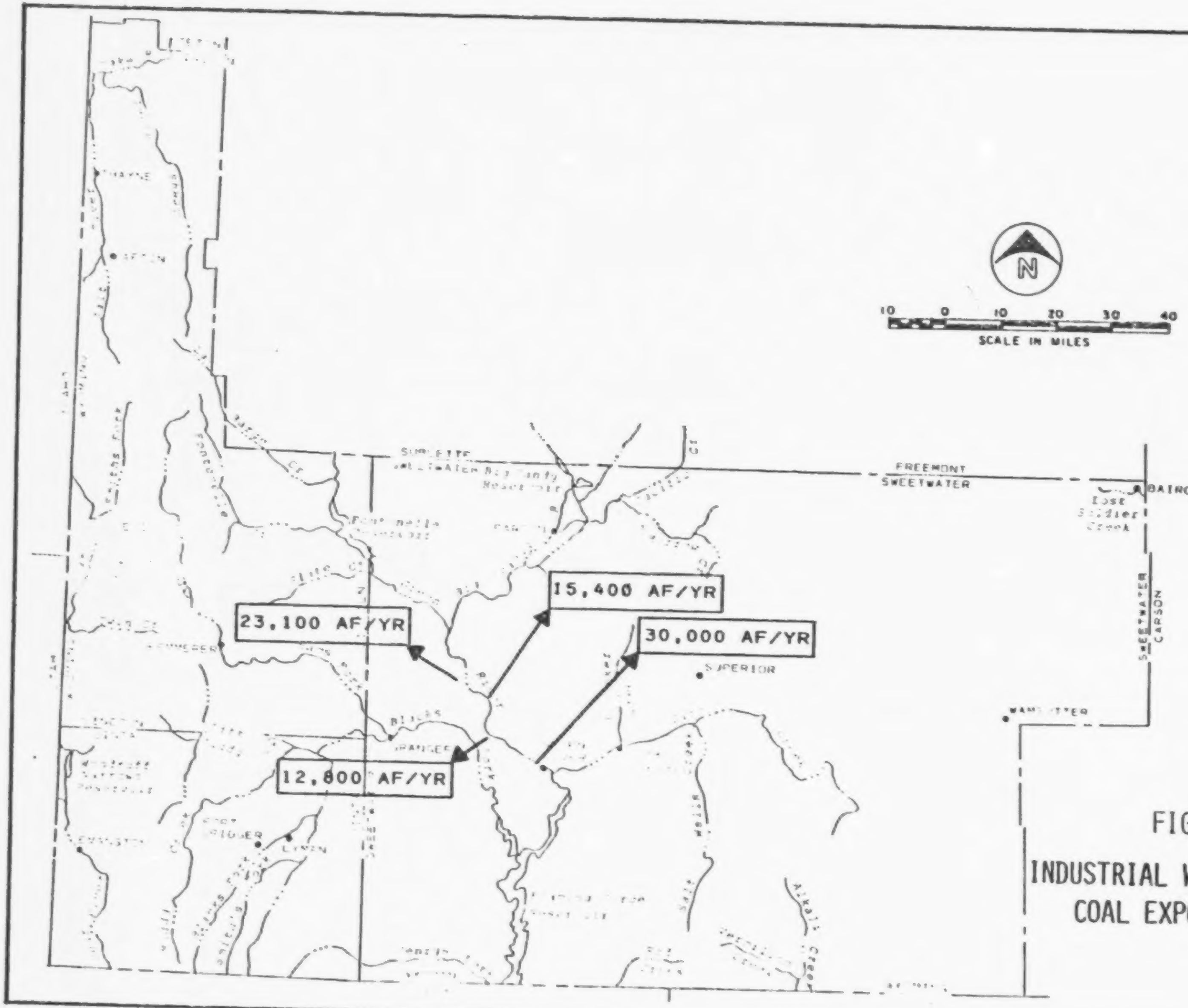
N
10 0 10 20 30 40
SCALE IN MILES
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
THAYNE
AFTON
Fontenelle Reservoir
KEMMERER
15,400 AF/YR
23,100 AF/YR
30,000 AF/YR
SUPERIOR
12,800 AF/YR
GRANGER
FORT BRIDGER
LYMAN
EVANSTON
WAMSUTTER
Alkali Creek

FIGURE 6-3

INDUSTRIAL WATER DEPLETIONS
COAL EXPORT YEAR 2000

CH2M HILL

(1) STATE WATER PLANNING FEELS THIS MAY COME FROM THE GREEN RIVER AREA

(2),(3) COULD BE MOVED TO THE AREA NEAR THE STATE LINE

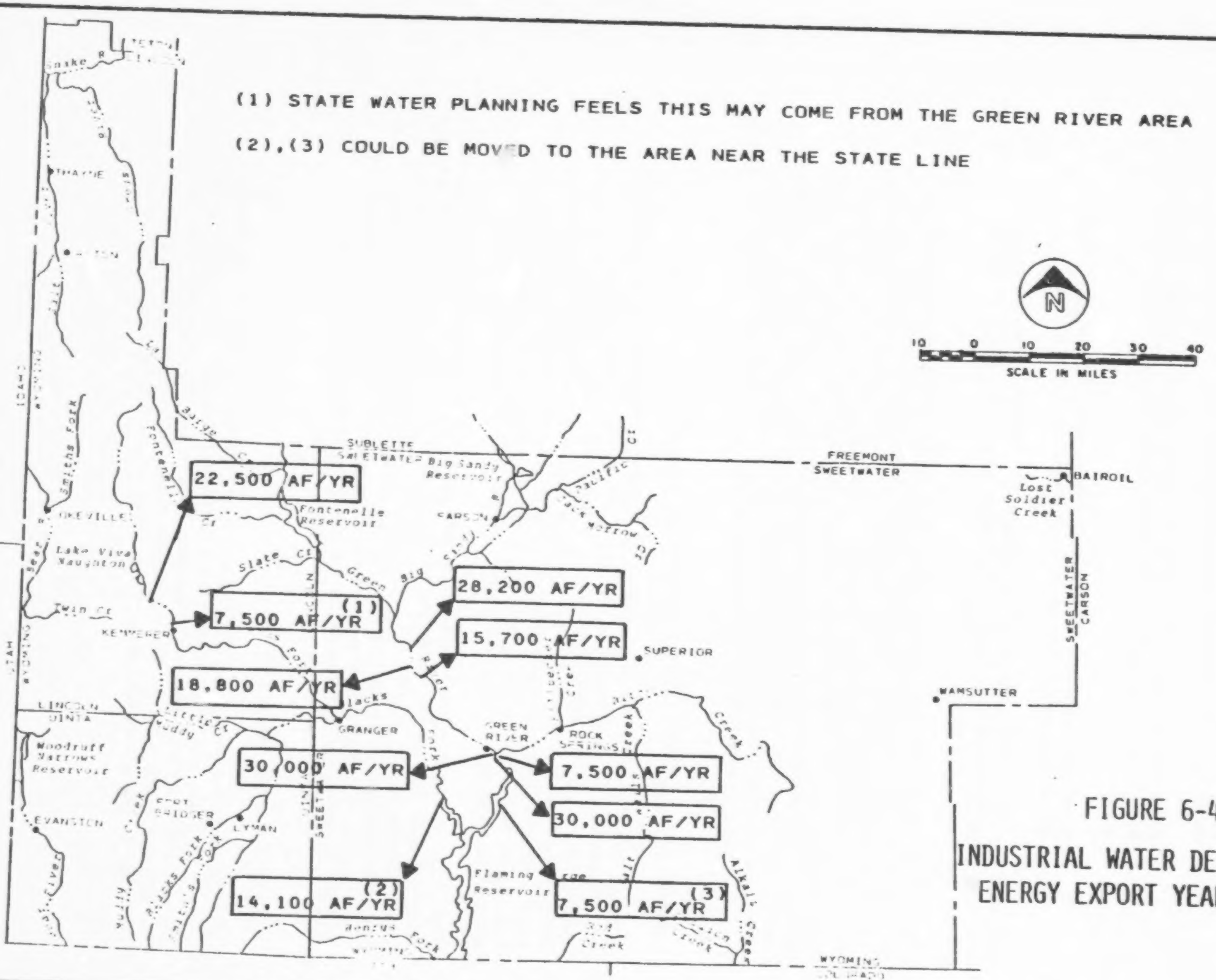
22,500 AF/YR
7,500 AF/YR (1)
18,800 AF/YR
28,200 AF/YR
15,700 AF/YR
30,000 AF/YR
14,100 AF/YR (2)
7,500 AF/YR
30,000 AF/YR
7,500 AF/YR (3)
SCALE IN MILES
10 0 10 20 30 40
N
SUBLETTE
SWEETWATER
FREEMONT
SWEETWATER
SWEETWATER
CARSON
LINCOLN
UINTA
IDAHO
WYOMING
UTAH
WYOMING
WYOMING
COLORADO
BAIROIL
Lost Soldier Creek
WAMSUTTER
SUPERIOR
ROCK SPRINGS
GREEN RIVER
GRANGER
KEMMERER
EVANSTON
LYMAN
FORT BRIDGER
KOKEVILLE
THAYNE
AFTON
Snake R
Smiths Fork
Bear
Lake Viva Naughton
Twin Cr
Slate Cr
Green
Big Sandy Reservoir
Fontenelle Reservoir
Fontenelle
Woodruff Narrows Reservoir
Flaming Gorge Reservoir
Alkali Creek
Creek
CARSON
Pacific
Blacks
Fork
Muddy
Little
Henrys Fork
Bitter Creek

FIGURE 6-4

INDUSTRIAL WATER DEPLETIONS
ENERGY EXPORT YEAR 2000

CH2M HILL

- Diversion of 92,000 acre-feet per year from Fontenelle Reservoir to identify the impacts of diverting high quality water

- Complete diversion of Big Sandy River (approximately 60,000 acre-feet in 1975) to identify the impacts of diverting highly saline water

- Complete diversion of Bitter Creek to identify the impacts of diverting water with high phosphorus concentrations

Although the last two scenarios are probably not realistic from an engineering or water rights standpoint, they have been retained in order to assess the most extreme conditions.

It is difficult to correlate projected water depletions and diversions for the 208 study area with those developed by the State of Wyoming for the Green River Basin because the 208 boundaries are not coterminous with the Green River Basin boundaries. However, with the assistance of the State, water demand projections have been made for that portion of the Green River Basin within the study area based on the energy export scenario, the coal export scenario, and a scenario developed by the State of Wyoming. These three projections are compared on Table 6-3. As shown in the table, the State of Wyoming projections approximate those developed for SWWQPA for the aggressive energy export scenario.

METHOD FOR PREDICTING FUTURE WATER QUALITY

The two depletion and three diversion scenarios developed in the previous section have been used to quantitatively predict the effects of future conditions on the concentrations of total dissolved solids, sulfate, and phosphorus. The scenarios describe different levels of depletions, diversions and population. These three variables are inputs to a computer simulation model called the Green River model. The model uses different combinations of these three variables to predict future water quality.

The Green River computer model is based on the U.S. Army Corps of Engineers model, Water Quality for River-Reservoir Systems. It has been fully described in a separate report (CH2M HILL, June 1977). Runs have been made by the Water Resources Research Institute (WRRI) at the University of Wyoming. The results of these runs are summarized in later sections of this chapter. A more complete description of the results is presented in three other reports (WRRI, 1977a; WRRI, 1977b; WRRI, 1978).

Application of the Model

The Green River model is termed a simulation model because it describes or simulates flows and constituent levels that happen under certain specified conditions in a river-reservoir system. There are provisions in the model for changing the quantity and quality of waters that enter the modeled area in order to test conditions other than those which have existed in the past.

Table 6-3

WATER DEPLETIONS AND DIVERSIONS IN YEAR 2000 FOR THE PORTION OF THE GREEN RIVER BASIN IN THE SWWQPA 208 AREA

(In acre-feet/year)

	SWWQPA		State of Wyoming
	Energy Export	Coal Export	
Industrial	174,300	103,800	168,800
Agricultural	114,000	114,000	114,000
Municipal	13,270	8,110	20,000
Other	23,300	23,300	23,300
Reservoir Evaporation	26,300	26,300	26,300
Transbasin Diversion	(1)	(1)	92,000
TOTALS	351,170	275,510	444,400

---

(1) Three different transbasin diversion scenarios have been developed.

The model is set up to account for the following list of constituents: temperature, dissolved oxygen, BOD, alkalinity, pH, carbon dioxide, ammonia, nitrate, nitrite, phosphorus, coliform, two forms of algae, zooplankton, detritis, total dissolved solids (TDS), suspended solids, and sulfate. The model has been used in this report to predict future conditions for phosphorus, algae, TDS, and sulfate, because these appear to be the most critical pollutants at the present time. The model is on the WRRI system and can be used in future studies to simulate levels of the other constituents.

The output data describe water quality at two points in the Green River, one at 1.7 miles below the confluence of Bitter Creek and the Green River and the other one in Flaming Gorge Reservoir. These two points have been selected to characterize future water quality because the quality of water at these points may be strongly impacted by population growth in the Rock Springs-Green River area and by diversions and depletions upstream. The single point in the reservoir describes average conditions throughout the reservoir. As noted in Chapter 3, the two arms are considerably more eutrophic than the main body of the reservoir. Therefore, the location in the reservoir which would most closely correspond to the modeling point would be somewhere near the confluence of the two arms and the main body. The approximate locations of the two points are shown on Figure 6-5.

The model predicts the effects of increased wastewater discharges and increased diversions and depletions on water quality at the two points shown on Figure 6-5. The model has tested existing condtions and seven different combinations of the two depletion scenarios and the three diversion scenarios. These eight combinations are outlined below:

- Existing (1975) conditions
- Year 2000 conditions under the energy export scenario, with phosphorus controls on wastewater discharges
- Year 2000 conditions under the energy export scenario, without phosphorus controls on wastewater discharges
- Year 2000 conditions under the coal export scenario, with phosphorus controls
- Year 2000 conditions under the coal export scenario, without phosphorus controls
- Year 2000 conditions under the energy export scenario, with diversion and consumptive use of 92,000 acre-feet per year from Fontenelle Reservoir
- Year 2000 conditions under the energy export scenario, with complete diversion and consumptive use of Big Sandy River
- Year 2000 conditions under the energy export scenario, with complete diversion and consumptive use of Bitter Creek

Certain boundary conditions were assumed in order to apply the model. It was assumed that the quality and quantity of water in the Green River as it

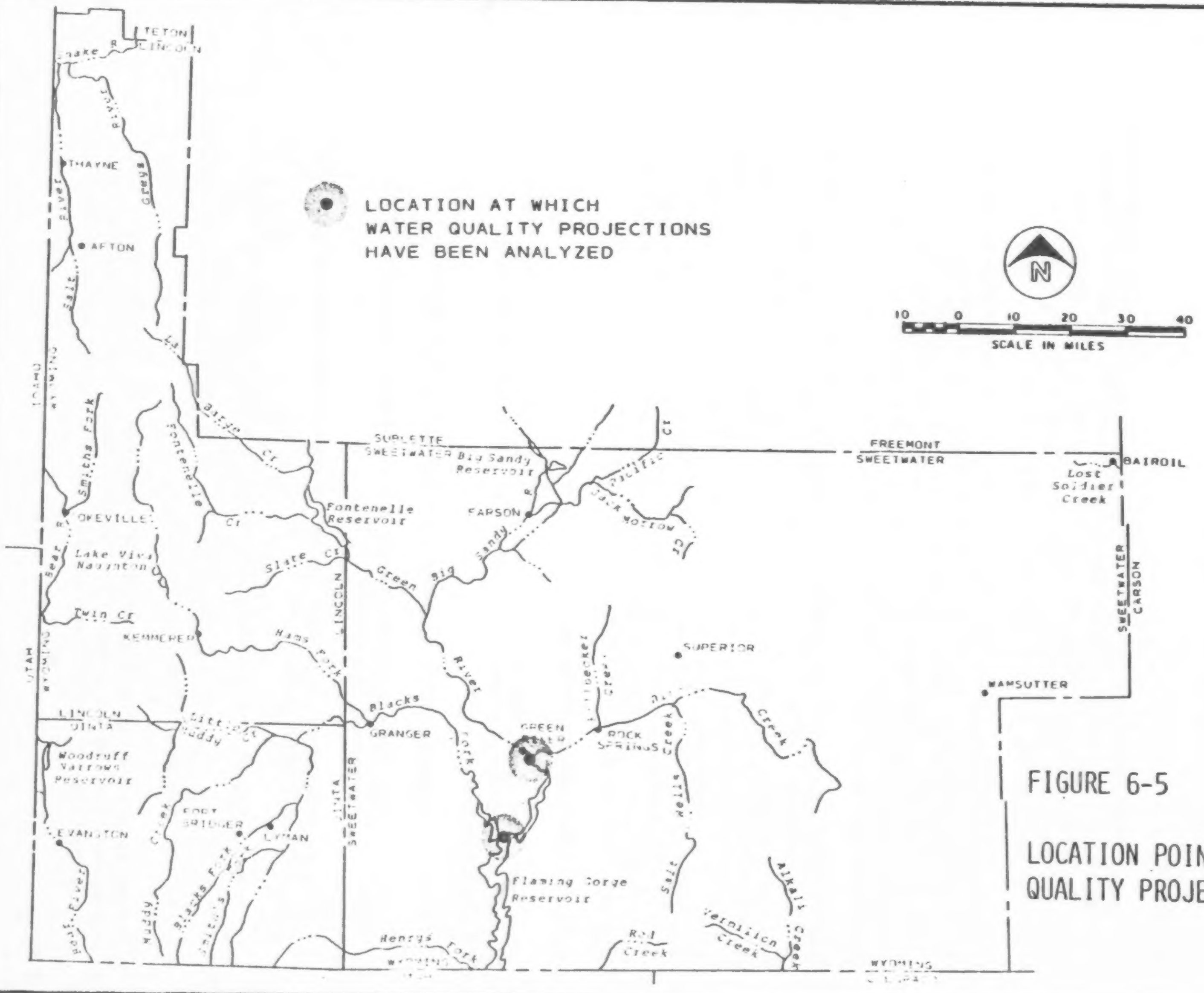
LOCATION AT WHICH WATER QUALITY PROJECTIONS HAVE BEEN ANALYZED
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Salt River
Greys River
IDAHO
WYOMING
Smiths Fork
OKEVILLE
Lake Viva Naughton
Bear R
Twin Cr
KEMMERER
Fontenelle Cr
La Barge Cr
SUBLETTE
SWEETWATER
Big Sandy Reservoir
FARSON
Fontenelle Reservoir
Slate Cr
Green River
Big Sandy
Pacific Cr
Jack Morrow Cr
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
SUPERIOR
Hams Fork
LINCOLN
UINTA
Blacks Fork
GRANGER
Killpecker Creek
GREEN RIVER
ROCK SPRINGS
Bitter Creek
Killpecker Creek
Little Muddy Cr
Woodruff Narrows Reservoir
EVANSTON
Bear River
FORT BRIDGER
LYMAN
Muddy Creek
Blacks Fork
Smiths Fork
Flaming Gorge Reservoir
Salt Wells Creek
Alkali Creek
Vermilion Creek
Red Creek
Henrys Fork
UTAH
WYOMING
COLORADO

FIGURE 6-5

LOCATION POINTS FOR WATER QUALITY PROJECTIONS

CH2M HILL

enters the study area would not change over the next 25 years. This assumption should be reviewed at the completion of the 208 study for Sublette County, if it is funded. Clearly quality and quantity changes in the Green River as it passes through Sublette County will have major impacts on the water quality of the Green River within the study area.

Calibration

The Green River model has been calibrated, which means that the mathematical expression used to describe conditions in the lower Green River and Flaming Gorge Reservoir has been adjusted specifically to account for known conditions in the Green River system. Thus, the model is not a generalized model but one specific to the Green River and Flaming Gorge Reservoir.

The model was calibrated for 1972 because that was the most coherent set of data available at the time the model was developed. Since that time, better data have become available for 1975 and 1976. The data that were available upon which to develop the model were not entirely adequate, and the report mentioned above strongly recommends that the model be recalibrated at some future period when a much better data set is available.

Model runs were made in this study for phosphorus and TDS with the better 1975 data in order to determine if the model, calibrated for 1972, could accurately predict 1975 conditions. Results from the 1975 runs are illustrated on Figures 6-6 and 6-7, where Figure 6-6 describes TDS levels and Figure 6-7 describes phosphorus levels in the Big Island reach of the Green River. The model adequately simulates TDS conditions during the period illustrated. While the simulation for phosphorus is not as close as that for TDS, a reasonable match is seen for the period from late May through early September. The reasons for the variation between simulated values and observed values are unknown at the present time.

FUTURE TDS AND SULFATE LEVELS

Five conditions have been selected from the eight mentioned in the previous section to illustrate the largest impacts of future actions on salinity. These five conditions are:

- Existing (1975) conditions for depletions and diversions
- Year 2000 conditions under the coal export scenario without phosphorus controls
- Year 2000 conditions under the energy export scenario without phosphorus controls
- Complete diversion and consumptive use of Big Sandy River
- Diversion and consumptive use of 92,000 acre-feet per year from Fontenelle Reservoir

The model has been used to predict the impacts of these conditions on TDS and sulfate levels in the Green River below Bitter Creek. In addition, the results from the model have been used to estimate the change in salinity

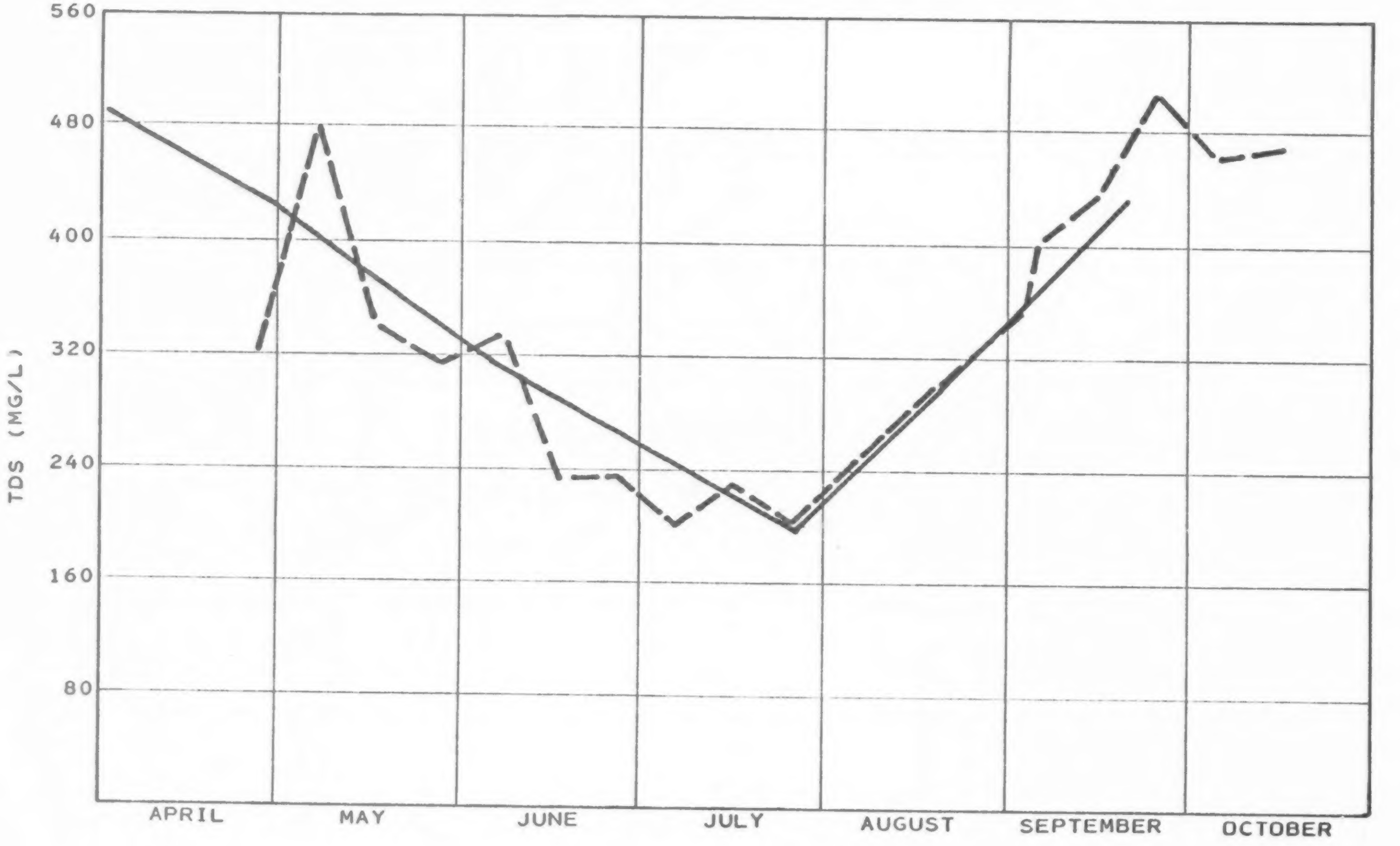

FIGURE 6-6

COMPARISON OF 1975 TDS CONCENTRATIONS
AT BIG ISLAND WITH MODELED RESULTS

CH2M HILL

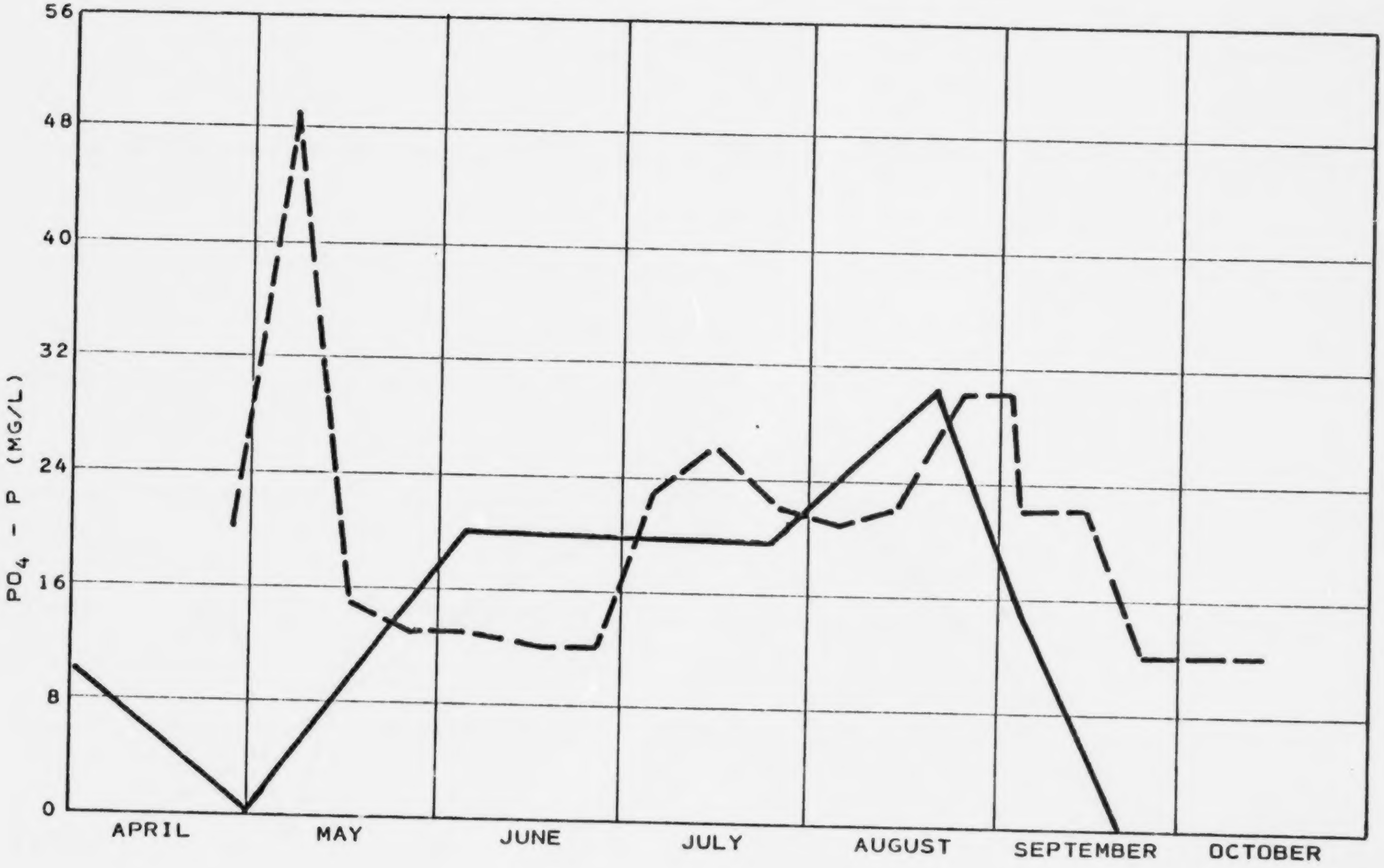

FIGURE 6-7

COMPARISON OF 1975 PHOSPHORUS CONCENTRATIONS
AT BIG ISLAND WITH MODELED RESULTS

CH2M HILL

experienced by downstream users, as measured in the Colorado River at Imperial Dam.

Future Salinity in the Green River

All of the five conditions listed above are predicted by the model to reduce salinity loadings in the Green River.(1) As shown on Figure 6-8, the Big Sandy diversion produces a 25 percent decrease in TDS loadings, while the Fontenelle diversion produces approximately a 10 percent decrease. A 5 percent decrease in salinity loads is predicted under the coal and energy export scenarios.

The predicted impact of future conditions on the salinity concentrations is illustrated on Figure 6-9. Surprisingly, future industrial depletions in the study area are predicted to have a small effect on TDS concentrations at the Green River modeling point. The increase in the maximum TDS concentration under the energy export scenario is 5 percent over the maximum simulated 1975 value. The increase is less under the coal export scenario. The reason for the insignificant increase under both the energy export and coal export scenarios is that the largest projected industrial depletions from the Green River are located in the stretch between Big Sandy River and the modeling point just below Bitter Creek (see Figures 6-3 and 6-4). This stretch has the highest TDS concentrations of any Green River stretch in the area. Therefore, industrial depletions from this stretch would not cause a concentration of the salt load in the study area. As shown later, however, it will cause a concentration of the salt load in the Colorado River.

The diversions from Big Sandy River and Fontenelle Reservoir are predicted by the model to have much greater impacts on TDS concentrations within the study area. The salinity concentrations in Big Sandy River are generally higher than those in the Green River below Bitter Creek. Therefore, as shown on Figure 6-9, diversion of the Big Sandy River would significantly decrease TDS concentrations in the Green River, particularly during the periods of highest TDS concentrations in the Green River. The diversion of Big Sandy is predicted to result in a 43 percent decrease in the maximum TDS concentrations from the simulated maximum 1975 levels.

The diversion from Fontenelle Reservoir is the converse to a diversion from Big Sandy River. Salinity concentrations in the Green River at Fontenelle Reservoir are lower than those in the Green River below Bitter Creek. Therefore, as shown on Figure 6-9, a diversion at Fontenelle Reservoir has

---

(1) All results are based on the apparent present situation where water diverted by industry and ponded in holding or evaporation basins does not return to the Green River through the ground water system. As discussed earlier, existing industrial ponds are apparently not in the recharge areas to surface waters. If future industrial ponds are constructed in ground water recharge areas, however, ground water may carry significant TDS loads back to the surface waters. In this case, the model would greatly underestimate the impact of energy development on salinity.

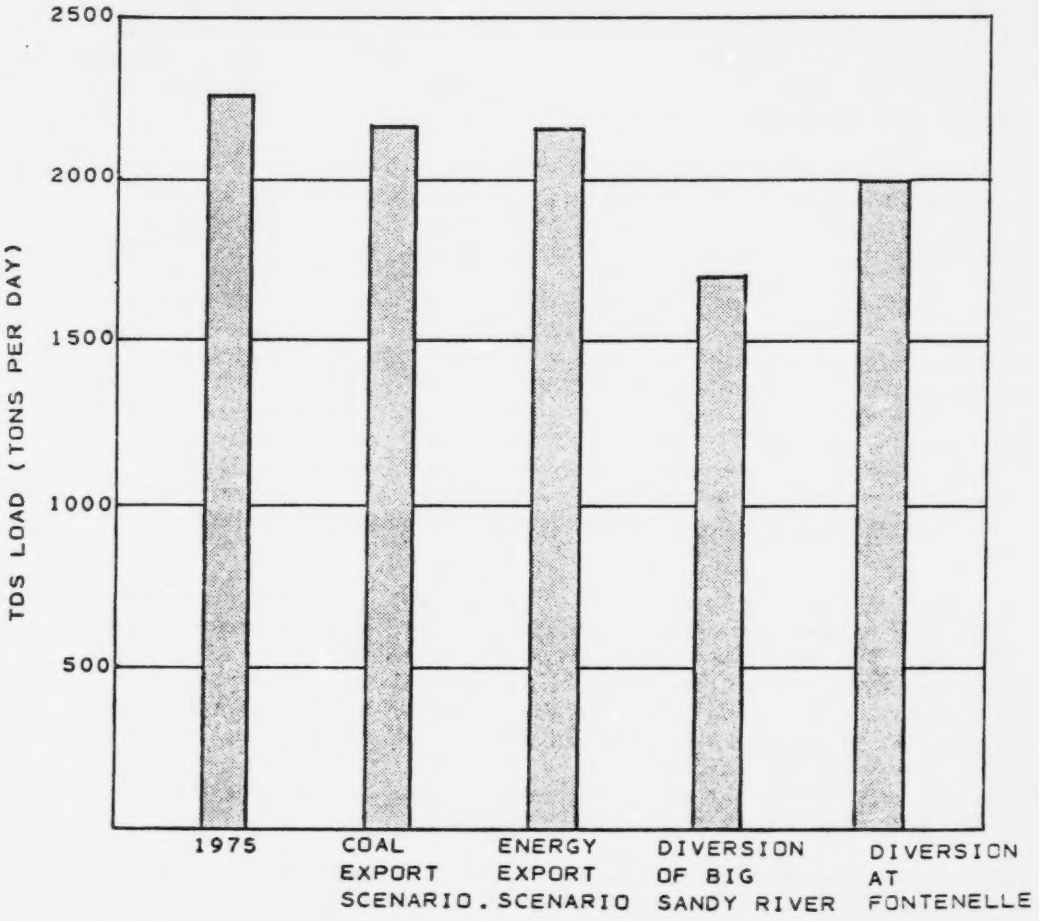

FIGURE 6-8

FUTURE TDS LOADS
IN THE GREEN RIVER

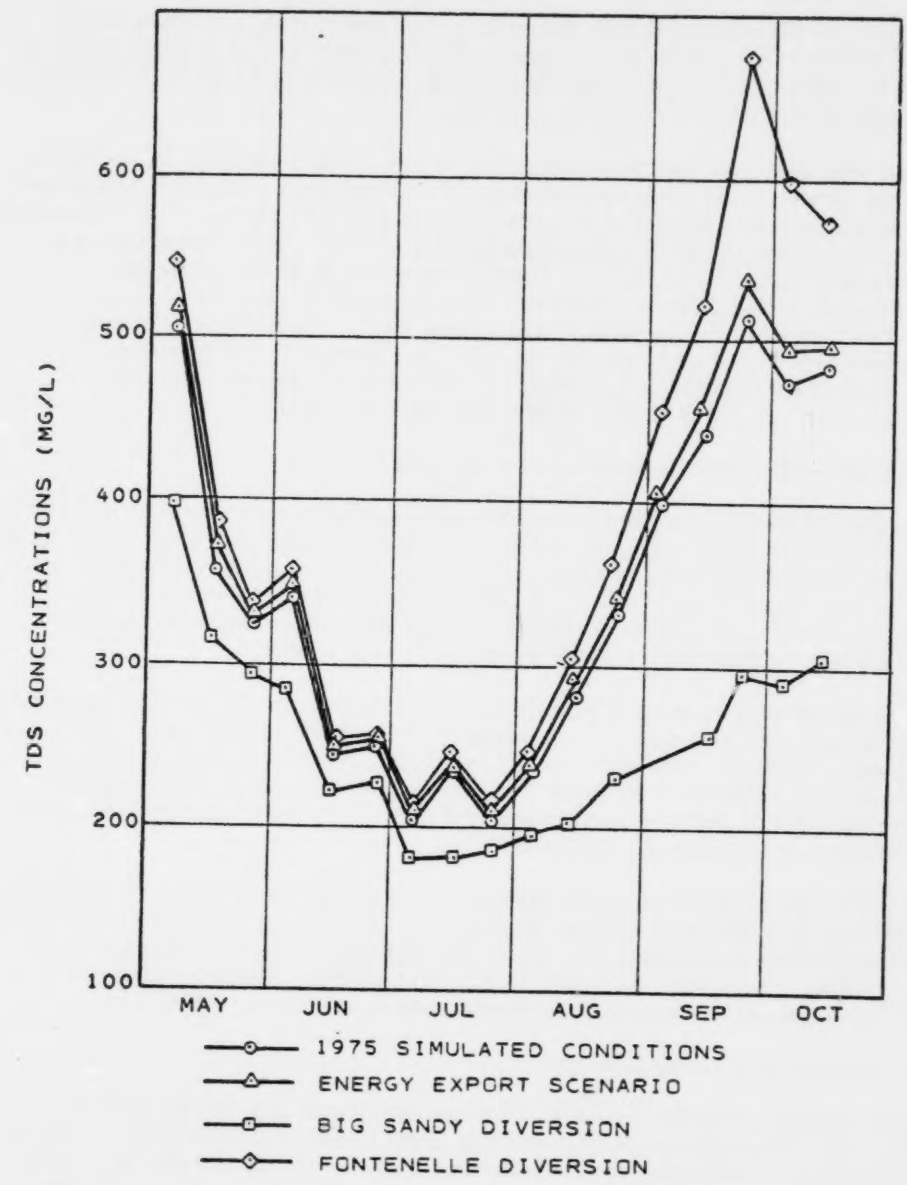

FIGURE 6-9

FUTURE TDS CONCENTRATIONS IN THE GREEN RIVER the effect of concentrating the salt load in the downstream reaches of the Green River. The greatest changes in TDS concentrations are predicted to occur during the relatively low-flow period in autumn, when TDS concentrations are at or near their annual maxima.

Sulfate was also modeled because of its health-related impacts in the Rock Springs-Green River area and because of its economic impacts to industries. The results are presented on Figure 6-10. As was found with TDS concentrations, depletions under the energy export and coal export scenarios are predicted to have little effect on sulfate concentrations in the Green River below Bitter Creek. However, diversion of Big Sandy River is predicted to decrease the sulfate concentration by 57 percent from the maximum concentration in the 1975 simulation run. By contrast, the Fontenelle diversion is predicted by the model to increase sulfate concentrations above the criterion for public water supplies (250 mg/l).

Future Salinity in the Colorado River at Imperial Dam

As indicated in Chapter 4, small changes in salinity concentrations in the lower Colorado River can have major economic consequences for water users. Actions in the study area which result in a change of the salinity load or flow in the Green River will affect salinity concentrations in the lower Colorado River. This section addresses the salinity impacts at Imperial Dam caused by four future conditions in the study area.

The numbers in this section should be taken with "a grain of salt" because of the assumptions that had to be made in order to calculate them. More accurate estimates of salinity impacts during a certain year or period of years can be obtained through the use of a Colorado River Basin salinity model which will include such important factors as routing, flow and salinity losses due to seepage, and others.

The estimated changes in mean salinity concentrations at Imperial Dam are presented on Table 6-4. Given the fact that the mean salinity concentration at Imperial Dam is already 762 mg/l, the changes in salinity appear relatively small. However, as noted in the next section, these relatively small changes have important economic consequences for water users.

Cost Impacts of Salinity Changes

The estimated economic impacts of future conditions are illustrated on Table 6-4. The estimation of costs has been based on information presented in Chapter 4. The analysis shows that either diversion scheme will have major economic consequences on water users both within the study area and downstream from it. The economic impacts under the coal export scenario are predicted to be relatively small, while those under the energy export scenario are small for users in the study area, but large for those downstream.

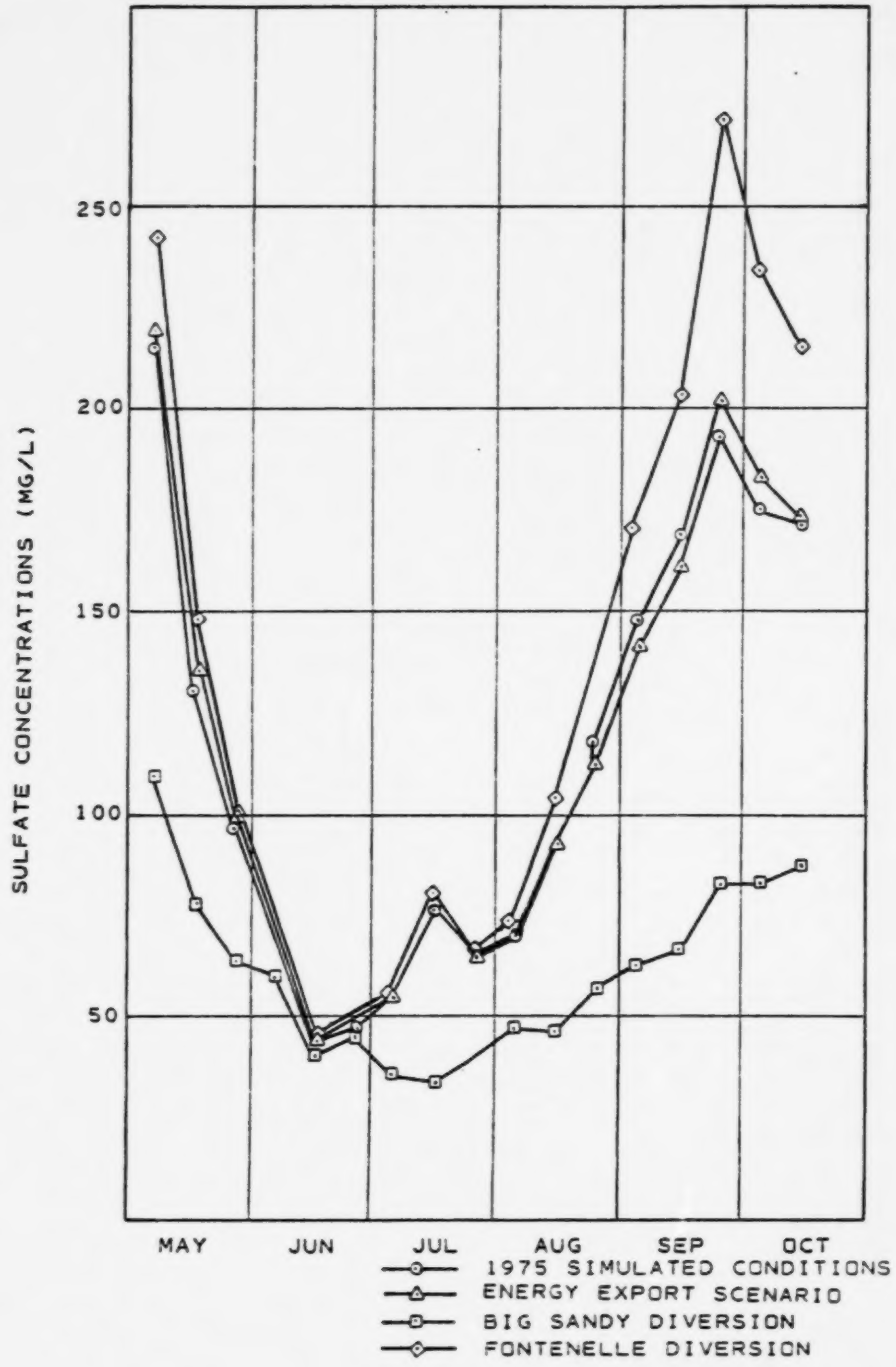

FIGURE 6-10

FUTURE SULFATE
CONCENTRATIONS
IN THE GREEN RIVER

CH2M HILL

Table 6-4

IMPACT OF FUTURE CONDITIONS ON WATER QUALITY AND COSTS

Condition	At Imperial Dam		In Lower Green River Reach		
	Change in Mean Salinity Concentration (mg/l)	Change in Cost to Downstream Users ($x10^6/yr)	Change in Mean Salinity Concentration (mg/l)	Change in Cost to Downstream Users ($x10^6/yr)	Total Chang in Cost ($x10^6/yr)
Year 2000, Coal Export Scenario	0	0	+3	0	0
Year 2000, Energy Export Scenario	+5	+2.2	+9	+0.3	+2.5
Year 2000, Big Sandy Diversion and Energy Export Scenario	-4	-1.7	-88	-4.0	-5.7
Year 2000, Fontenelle Diversion and Energy Export Scenario	+7	+3.0	+35	+1.5	+4.5

FUTURE PHOSPHORUS AND ALGAE LEVELS

Figure 6-11 shows the predicted phosphorus loads in the Green River below Bitter Creek under present conditions and seven different scenarios of future conditions. Large increases in phosphorus loads are predicted under both the coal export and energy export scenarios unless point source controls on phosphorus are instituted. The reason for these increases is the large population growth and increased wastewater loadings associated with the energy development. With point source controls, the phosphorus loads can be brought back to approximately existing levels.

Figure 6-11 also shows that diversions can reduce phosphours loads from their predicted levels in year 2000. Diversion of Bitter Creek would result in a 52 percent reduction in the phosphorus load within the framework of the energy export scenario. The load reduction by diversion of Bitter Creek would be equal to that obtainable by phosphorus control of point sources. This option to point source control may be economically and technologically feasible. However, it may face legal and political impasses at this time.

The effects on the reservoir of the higher phosphorus loadings are indicated on Figure 6-12 for the coal export scenario and on Figure 6-13 for the energy export scenario. These figures show the predicted average concentration in year 2000 over the entire reservoir at a depth of 10 feet. The simulated 1975 results are valuable for comparison to the predictions.

As shown on the two figures, peak phosphorus concentrations in the reservoir are shown to increase under both scenarios. The increase in the maximum concentration is 11 percent under the coal export scenario and 20 percent under the energy export scenario. According to the simulation runs, the phosphorus increases will cause the algal concentrations during the severest bloom to increase by 14 percent under the coal export scenario and by 21 percent under the energy export scenario. Algal concentrations are predicted to increase by even larger percentages during smaller blooms in May and June under both scenarios.

The two figures also show that point source controls on phosphorus can lower phosphorus concentrations predicted in the reservoir for year 2000 down to approximately the existing (1975) levels. However, the existing conditions in the reservoir are not considered desirable for recreational use. Therefore, point source controls alone probably cannot produce desirable conditions in the reservoir.

This important conclusion is further illustrated on Figure 6-14. Information presented on the previous two figures has been used to construct a graph of phosphorus loading to the reservoir versus peak phosphorus concentration in the reservoir. In addition, the relationship between phosphorus concentrations and clarity depicted on Figure 2-5 has been incorporated into the figure. The resulting graph shows the predicted clarity during the worst algal bloom (simultaneous with the peak phosphorus concentration) for the different future conditions.

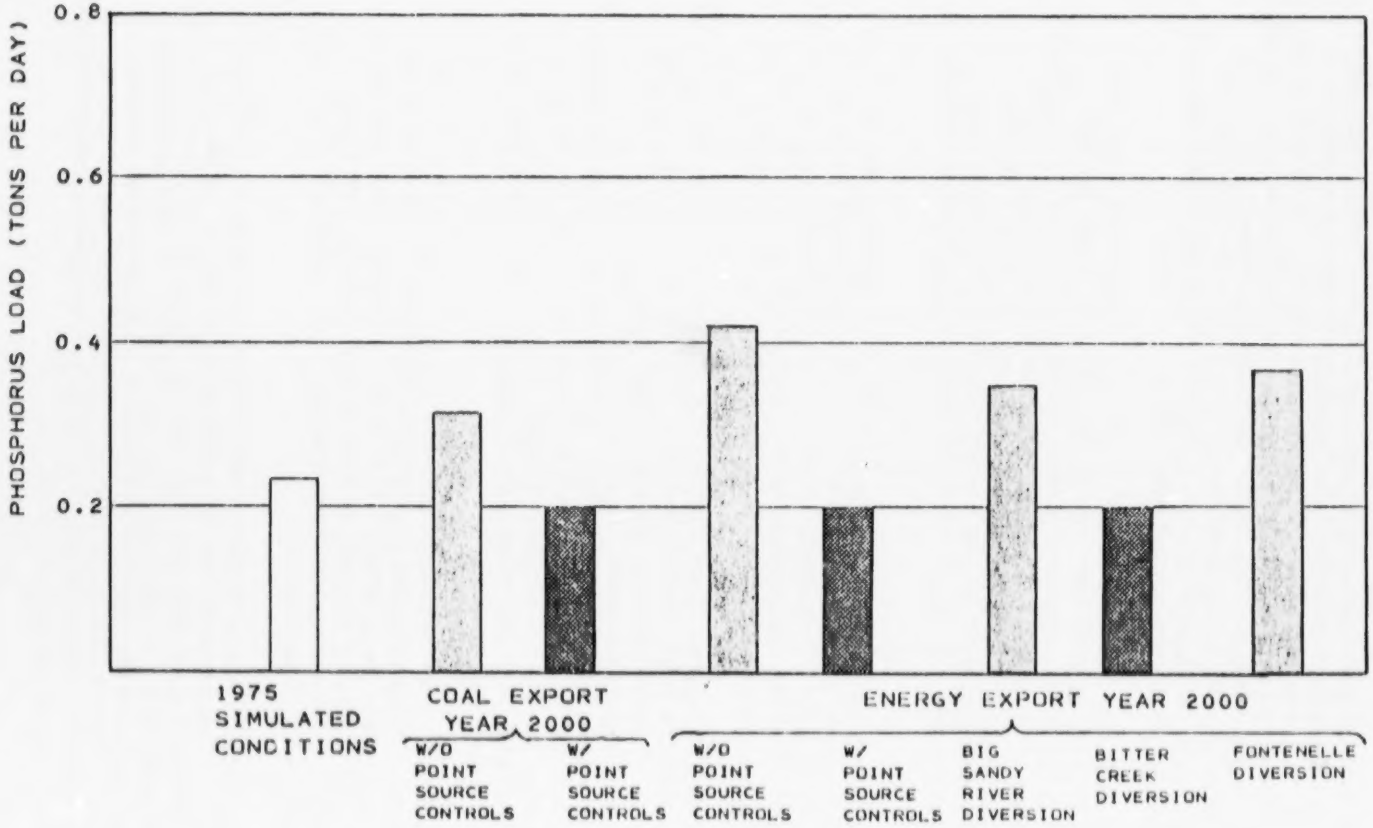

FIGURE 6-11

FUTURE PHOSPHORUS LOADS
IN THE GREEN RIVER

CH2M HILL

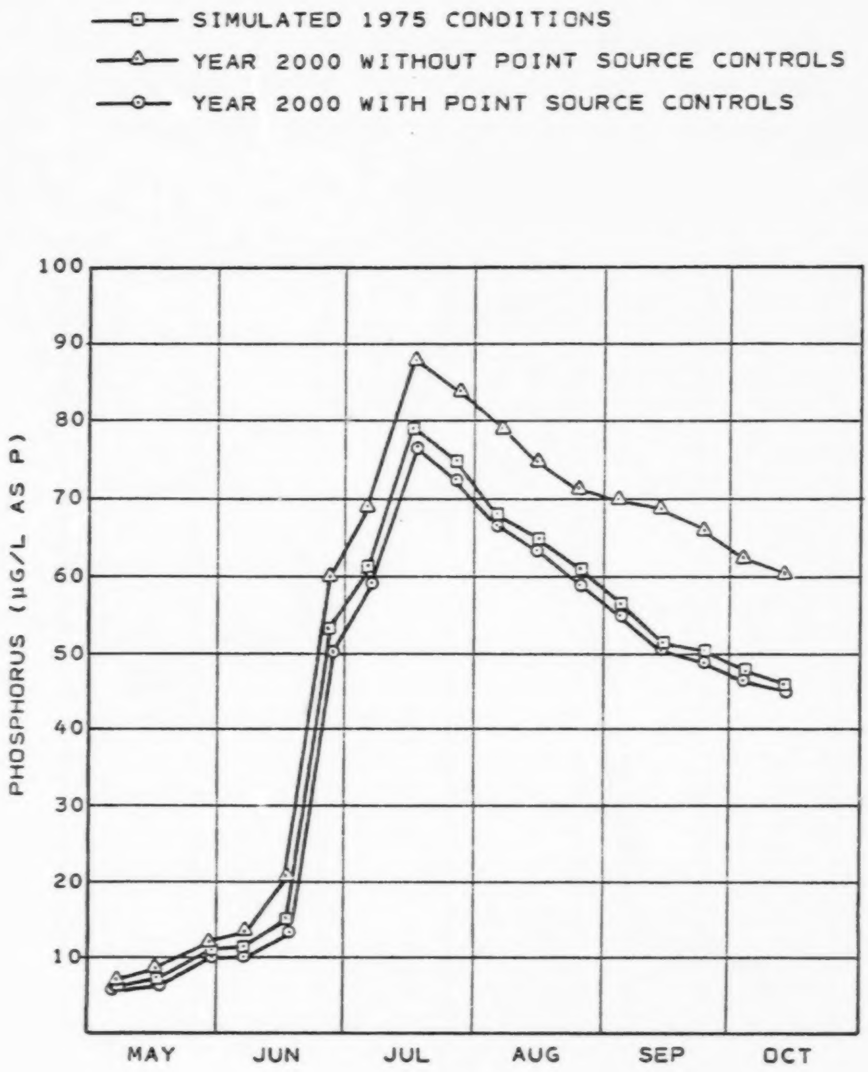

FIGURE 6-12

AVERAGE PHOSPHORUS CONCENTRATIONS IN FLAMING GORGE RESERVOIR UNDER THE COAL EXPORT SCENARIO

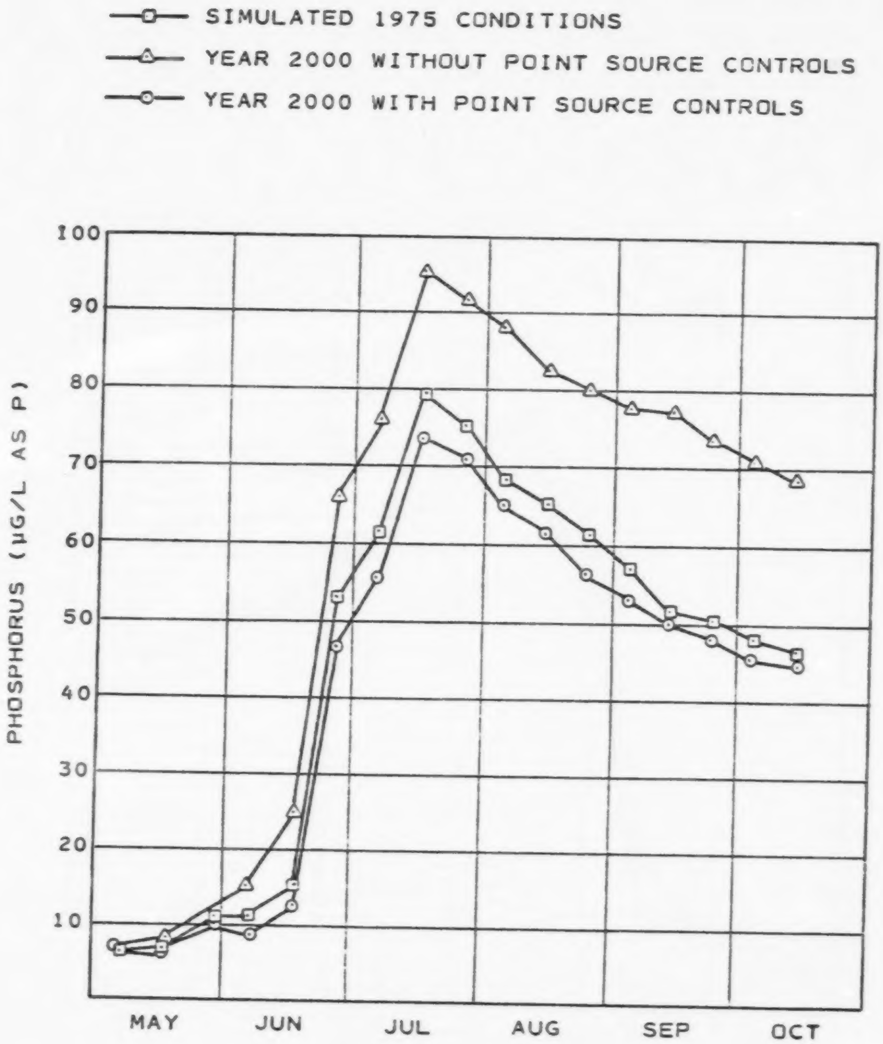

FIGURE 6-13

AVERAGE PHOSPHORUS
CONCENTRATIONS IN
FLAMING GORGE RESERVOIR
UNDER THE
ENERGY EXPORT SCENARIO

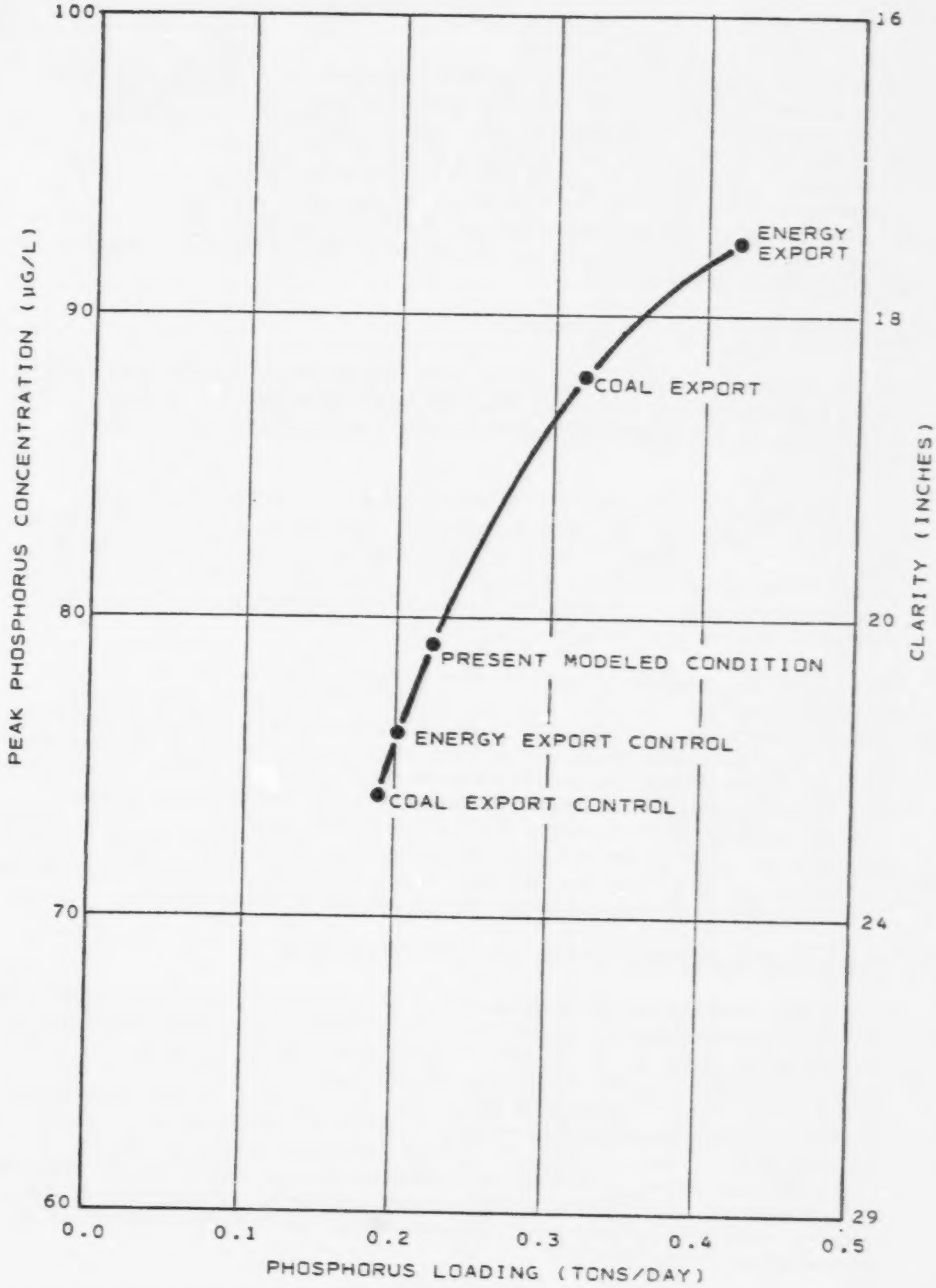

FIGURE 6-14

PREDICTED CHANGES IN CLARITY
FOR FUTURE CONDITIONS

None of the future conditions, including those with point source controls, is predicted to significantly affect the clarity of the water during the worst algal bloom. For example, point source controls are estimated to increase clarity by only 1 to 2 inches during the most severe bloom. Therefore, point source controls are predicted to produce no significant aesthetic improvements in the reservoir. If instituted without controls on erosion and other phosphorus sources, their only possible benefit might be some immeasurable slowing in the rate at which eutrophication is spreading downstream in the reservoir.

CHANGES IN OTHER POLLUTANTS

Fecal coliform and dissolved oxygen were identified in Chapter 3 as widespread water quality problems. Sources were identified for these pollutants in Chapter 5. Loadings from some of these sources may increase in the future.

A major source of fecal coliform in the study area is effluent from point sources. Population increases in Rock Springs, Green River, and Kemmerer-Diamondville will increase fecal coliform loadings in the municipal wastewater treatment plant effluents unless disinfection is added to the existing treatment processes. Therefore, fecal coliform problems may become more severe in the streams below these areas.

Two major sources of dissolved oxygen problems are municipal treatment plant effluents and biodecay. As with fecal coliform, dissolved oxygen depletion may become increasingly severe in the lower reaches of the Green River and Hams Fork because of greater point source loadings from the Rock Springs-Green River area and the Kemmerer-Diamondville area. Point sources may also encourage more severe dissolved oxygen depletion by delivering greater loadings of phosphorus to the streams and reservoirs. These greater phosphorus loadings can promote increased algal growth and decay. As noted in Chapter 5, this decay may already be an important cause of oxygen depletion in the Snake River and Green River just above the reservoirs.

SUMMARY OF FUTURE WATER QUALITY PROBLEMS

The major reason why Southwestern Wyoming received funds for a water quality management plan was the potentially serious impacts of energy development on the water resources in the area. Coal, oil and gas, oil shale, uranium, trona-- all these valuable resources are present in great quantities in Sweetwater, Lincoln, and Uinta Counties. Development of these resources may affect water quality. The primary impacts on surface water and ground water quality of recovering these mineral resources appear relatively slight because of the location of the proposed mining. However, as described in this chapter, the secondary impacts may be severe. A summary of the relative importance of secondary impacts under the different conditions is presented on Table 6-5.

The conclusions in this chapter are based on the water diversion and depletion scenarios shown on Figures 6-2 through 6-4 and the population projections listed on Table 6-1. It must be emphasized that different scenarios

Table 6-5

FUTURE WATER QUALITY IMPACTS

Future Condition	TDS in the Green River	TDS Downstream	Sulfate in the Green River	Eutrophication in Flaming Gorge
Coal Export Scenario	0	0	0	-1
Energy Export Scenario	0	-1	0	-1
Big Sandy Diversion	+2	+2	+2	
Fontenelle Diversion	-2	-2	-2	
Bitter Creek Diversion				+1
Point Source Controls	0	0	0	+1

KEY

+2	Major positive impact
+1	Some positive impact
0	No important impact
-1	Some negative impact
-2	Major negative impact

and projections may produce different conclusions about future water quality impacts.

Salinity impacts have been estimated for water users in the study area as well as downstream. Surprisingly, insignificant increases in salinity concentrations within the study area are predicted under both the coal export and the energy export scenarios. However, the energy export scenario is predicted to cause a small, but economically important increase in salinity concentrations in the lower Colorado River. The two diversion conditions will cause important changes in salinity concentrations both within the study area as well as downstream.

No major impacts have been assigned to any of the conditions in the case of eutrophication, because severe algae blooms are expected to persist under any of the conditions. The coal export and energy export scenarios may increase the rate at which eutrophication is spreading downstream in Flaming Gorge Reservoir by some indeterminable amount, while point source controls and diversion of Bitter Creek may slow the rate. However, the quantifiable impacts on phosphorus concentrations and water clarity appear slight for all the conditions.

Chapter 7
EXISTING INSTITUTIONAL FRAMEWORK

A 208 Plan must include an institutional framework for implementing a water quality management plan. The institutional framework identifies who will carry out, manage, enforce, fund, and monitor the water quality controls.

In U.S. EPA's *Guidelines for Areawide Waste Treatment Management Planning* (August 1975), it is emphasized that management planning "...should be conducted concurrently and in coordination with technical planning. Management planning should identify water quality management problems and analyze the capability of existing agencies and arrangements to carry out the regulatory and management requirements of Section 208. Institutional problems, lack of authority, or lack of financial capacity for meeting Section 208 requirements should be identified."

This chapter describes the capabilities that agencies must have within the context of 208 planning and identifies the agencies now present that have those capabilities. This information is summarized on Table 7-1. This table identifies six specific management capabilities or functions that are required to implement a control program. Each management agency may be responsible for one or more of these functions. The currently responsible agencies are also identifed on Table 7-1 according to 10 different pollution sources or pollution control areas. The table identifies only management agencies. These agencies will call on technical specialists at certain points to identify problems and develop solutions.

In specific cases, the lines of authority and responsibility may not be as clearly defined as might be implied by the simplified listings on Table 7-1. As an example, responsibility for regulation and control of individual residential sewage is now being worked out between the State, DEQ and the counties and cities. DEQ has offered this responsibility to the counties, but the counties have generally turned down the offer because of lack of funding needed to carry out the responsibility. In the case of urban runoff, very little is actually being done at the present time, and virtually nothing is being done from a water quality standpoint. On the other hand, there is much activity with regard to municipal sewage sources contributing to stream salinity and sediments and water quantity management. Because these sources or activities have traditionally been considered important, they have the most clear cut definitions of responsibilities and authorities at this time. A major function of 208 planning is to clarify the lines of authority associated with water quality and to pull together the independent activities of the various responsible agencies so that all are heading in the same direction to accomplish the same basic purpose.

EXISTING AGENCIES BY MANAGEMENT FUNCTIONS AND POLLUTION SOURCES

Source Type or Activity	Plan	Finance	Administer, Oversee Activities	Regulate, Enforce, Monitor	Construct Facilities, Enact Laws or Ordinances, or Develop Regulations	Operate Facilities
Municipal Sewage	Local Government(5) and DEQ, SWWQPA	EPA, DEQ, Local(5)	Local(5)	DEQ, EPA	Local(5)	Local(5)
Industrial Wastewater (Fuel and Nonfuel Minerals, Basic Industry, Electric Generation)	Individual, SWWQPA	Individual	WPSC, DEQ	DEQ, WPSC, EPA	Individual	Individual
Individual Residential Sewage	Individual, SWWQPA	Individual	City, County, DEQ(1)	City, County, DEQ(1),	Individual	Individual
Discharges From Agricultural Lands	*Individual, With Assistance of LCD, FMHA and SCS(2), SWWQPA, DEQ	*Individual, WCC, FMHA, SCS(4), ASCS	*Individual With LCD Assistance(2), WCC, FMHA, SCS(7)	(Water Quality Impacts) DEQ, WCC	*Individual With LCD Assistance(2), WCC, SCS(4)	Individual
Urban Runoff (Cities Over 5000 Population)	Local, SWWQPA	Local	Local	DEQ	Local	Local
Highway Construction	*WHD or County Highway Department(3) SWWQPA	*WHD or County Highway Department(3)	*WHD or County Highway Department(3)	DEQ, WHD	*WHD or County Highway Department(3)	*WHD or County Highway Department(3)
Silviculture Runoff (Mostly Public Lands)	FS, SWWQPA, BLM, SF	FS, BLM, SF	FS, BLM, SF	FS, DEQ, BLM, SF	FS, Operators, BLM, SF	FS, Operators, BLM, SF
Grazing Land Runoff (From Public Lands)	BLM, SWWQPA	BLM	BLM	BLM, DEQ	BLM, Grazers	BLM, Grazers
Environmental Salinity and Sediments	Interior, BR, SWWQPA, SCS(2), BLM	Interior, EPA, BR, SCS(4), ASCS, BLM	Interior, EPA, BR, BLM	Interior, EPA, BR, SCS, DEQ, BLM	Interior, EPA, BR, SCS(4), BLM	Interior, BR, BLM
Recreational Area Wastewaters	NPS, FS, WRC, SWWQPA, City, County	NPS, FS, WRC, City, County	NPS, FS, WRC, City, County	DEQ	NPS, FS, WRC, City, County	NPS, FS, WRC, City, County
Water Quantity Management	SE, SWWQPA, COE	State Legislature, COE, County	SE, COE	SE, DEQ, USGS	COE, DEPAD(6) Legislature	COE, DEPAD(6)

Abbreviations:

SWWQPA	Southwestern Wyoming Water Quality Planning Association
LCD	Local Conservation Districts
WCC	Wyoming Conservation Commission
WHD	Wyoming Highway Department
WRC	Wyoming Recreation Commission
DEPAD	Wyoming Department of Economic Planning and Development
SF	Wyoming State Forester
SE	Wyoming State Engineer
DEQ	Wyoming Department of Environmental Quality
WPSC	Wyoming Plant Siting Council
COE	U.S. Army, Corps of Engineers
EPA	U.S. Environmental Protection Agency
FMHA	U.S. Department of Agriculture, Farmers Home Administration
SCS	U.S. Department of Agriculture, Soil Conservation Service
FS	U.S. Department of Agriculture, Forest Service
ASCS	U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service
BLM	U.S. Department of the Interior, Bureau of Land Management
BR	U.S. Department of the Interior, Bureau of Reclamation
NPS	U.S. Department of the Interior, National Park Service
USGS	U.S. Geological Survey

* These items include changes from what is now done.

(1) Decisions are currently being made on the subject of who is to have jurisdiction.
(2) These arrangements are now available on a voluntary basis.
(3) Highway departments are now active in quantity control, associated with their roadway responsibilities.
(4) RC&D and small watershed programs.
(5) Includes special districts and joint powers entities as local government.
(6) Only if specifically authorized by State legislature.
(7) Technical assistance programs.

The remainder of this chapter describes the various agencies now involved directly or indirectly in water quality management in the Southwestern Wyoming area. Local as well as State and Federal agencies are discussed. Numerous other agencies, such as the State Highway Department and the State Departments of Public Lands, Forestry, and Land Use Administration, are not discussed in this chapter because they do not have nor are they expected to have major roles in water quality management in the future. Some of these agencies may be involved in water quality, but they are not expected to have an important part in this particular plan.

AUTHORITIES AT LOCAL LEVEL

Local Government

Local government is defined here as including towns and cities, as well as special districts and entities formed under joint powers agreements. These agencies usually operate the wastewater collection and treatment facilities for municipal sewage. The cities and towns are also responsible for urban runoff.

Local governments have broad powers to act within their jurisdiction, but usually rely on the State or Federal government to do broad planning and such functions as setting water quality goals or effluent requirements. The cities and towns can also act to require septic tank standards and offer nonstructural controls.

Jurisdiction is not limited to the corporate boundary. For example, municipalities can have jurisdiction within 5 miles of the corporate limits for enforcement of health or quarantine regulations, and within 1/2 mile for all matters except taxation. This authority is granted under W.S. 15.1-171. It allows municipalities to be involved in sewage system planning outside its limits in order to better plan and manage how sewage collection is to be done in the areas immediately surrounding the city and to better plan for such concerns as treatment capacity. Rock Springs has already taken this authority in its area.

County Government

Ordinances that regulate installation of individual waste disposal systems, that regulate where and how certain development can take place, and that establish special water and sewer districts are all part of county authority. The county government can also establish needed funding for such activities through fees or taxation.

The county government in a growing area plays a potentially strong role in shaping the future because so much of the growth is likely to happen in unincorporated areas subject to possible annexation later.

Joint Powers Boards

Wyoming statutes provide that municipalities, counties, special districts, and other agencies can perform the same actions jointly that any one agency can do separately. Two municipalities, for example, could form a joint powers board to build a sewage treatment plant or collection system. A county and municipality could assume the same powers as a county and special district or a municipality and special district. Through such joint powers boards, facilities could be extended from a municipality to the surrounding area, without the need for annexation.

The Wyoming Joint Powers Act is just now coming into use in the study area, but more use is expected in the future. These provisions are a logical combination with the extraterritorial jurisdiction powers available to first class cities and provide extension of some of the extraterritorial benefits to municipalities other than first class cities, even to unincorporated areas.

AUTHORITIES AT REGIONAL LEVEL

Southwestern Wyoming Water Quality Planning Association

The Southwestern Wyoming Water Quality Planning Association (SWWQPA) is the key regional agency. At this time the single purpose of SWWQPA is to conduct the planning program to develop a 208 Plan. However, it can serve in a capacity as a regional management agency in the future. In the absence of SWWQPA, the Lincoln-Uinta Association of Governments could serve as the regional water quality management agency for those two counties.

Colorado River Salinity Control Forum

The Colorado River Salinity Control Forum (CRSF) is an advisory group composed of water resource and water quality representatives from the seven Colorado River Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. CRSF has provided the member states and the U.S. Environmental Protection Agency with information on salinity standards and salinity control programs for the Colorado River Basin. While CRSF is more of a research and technical assistance group than a managing agency, it has developed management programs for other agencies.

AUTHORITIES AT STATE LEVEL

Department of Environmental Quality

According to information from the Department of Environmental Quality (DEQ) and the State Attorney General's office, the Act enabling and establishing Wyoming DEQ provides a very broad authority for this agency to act in matters of water quality management and wastewater treatment. The Department is associated with two citizen groups so that its proposed actions can get popular review. The Wyoming Water Quality Advisory Board consists of five members appointed by the Governor. The Board consists of one member from industry, one from agriculture, one from political subdivision, and two representing the public interest. The Environmental Quality Council is a council of citizens who are appointed politically and who serve 4-year terms. The Council and Board in association with DEQ can provide both the broad base of popular citizen support as well as the already established legal authority to act.

Important activities for DEQ are operating the permit program under the NPDES, administering the grant program for municipal treatment facilities, maintaining facility operation, certifying treatment plant operators, and developing the State's water quality standards. This agency also monitors water quality conditions in the State and administers the public water supply program. The Land Quality Division of DEQ reviews and approves mine permit applications and monitors mine plans to ensure that they are properly implemented.

Any procedure or regulation adopted by DEQ is subject to judicial review and so is not necessarily final by a unilateral decision of DEQ. In the enabling act there are savings clauses that exempt the activities of the State Engineer from being within the authority of DEQ. These activities include water quantity management, activities associated with wells for oil and gas exploration, and activities associated with wells for minerals.

The authority of DEQ is not limited to point sources or surface streams. The agency can also be responsible for nonpoint sources and ground water.

DEQ has jurisdiction over the entire State, and its enforcement actions can be filed in either Laramie County or the county in which the problem arises. Laramie County is usually used for filing actions, because the judges there are familiar with the kinds of actions under DEQ's jurisdiction. If a city or county were to bring action, it would be heard in a District Court, unless the action was considered a misdemeanor (which has a fine less than $100). All injunctions have District Court venue. The advantage to having the State act in these matters is the State does not have to post bond to bring injunctions, whereas private individuals do.

The State Engineer

The State Engineer is primarily responsible for water quantity management. Questions concerning water rights and the distribution in time and space of the surface waters of the State are the responsibility of the State Engineer. The State Engineer also has authority to act in matters of water quality, but apparently has not used the authority and is not likely to because of the presence of DEQ. One possible water quality issue that may involve the State Engineer concerns sediments and salinity, because the management and control of water diversions can affect the impact of these constituents on quality. Thus, management plans for sediments and salinity may include action by the State Engineer. The State Engineer also would be involved in at least an advisory capacity in interstate salinity compacts, which may have the effect of restricting Wyoming's full development of compact water.

The State Engineer has responsibility over the development of ground water. However, the State Department of Health and Social Services is involved in regulation of ground water quality for domestic or public water supplies, and the State Land Commission is involved in reclamation.

Department of Agriculture

One of the prime activities of the State Department of Agriculture (SDA) is to work with individual farmers through the local conservation districts. Within the Southwestern Wyoming 208 planning area, there are four local conservation districts and parts of two others. Districts 3 and 7 are located in Lincoln County; District 35 is primarily in Uinta County; District 45 is primarily in Sweetwater County; and portions of Districts 7, 16, and 39 are also in Sweetwater County. Districts 3, 7, 35, and 45 are all within the Wyoming Association of Conservation Districts Area 5. The conservation districts are considered to be an arm of State government and are operated through the State Conservation Commission as part of SDA.

At the present time the main function of these districts is to carry out a district-wide conservation program directed at solving soil, water, and related resources questions. Districts utilize cooperative agreements with individual land users and units of government to provide technical assistance for conservation planning and application on individual land holdings. The agreements are voluntary; the land user agrees to plan, apply, and maintain appropriate conservation treatment measures with the technical assistance of the districts.

People interviewed from the districts and from SDA feel that the cooperative agreement vehicle is most appropriate for regulation of both discharges from agricultural lands as well as rural runoff from the smaller communities in these rural areas. However, it is possible to make the cooperative agreement a mandatory requirement rather than a voluntary act. The local districts could play a major role in implementing such a plan.

State Conservation Commission

The Wyoming State Conservation Commission (WCC) assists and guides the six local conservation districts (LCD) located within the study area. WCC is the State agency designated by the Governor to review and approve small watershed projects and RC&D project applications and plans. WCC sets priorities and direction for Soil Conservation Service activities on small watershed projects, and can accelerate work on these projects by employing consultants. As a complement to these responsibilities, WCC has recently been designated as the State agency responsible for the management of nonpoint source pollution resulting from agricultural activities.

The Interdepartmental Water Conference

In 1973 the State Legislature passed a law formalizing and providing for guidance of the Interdepartmental Water Conference (IDWC) in the planning of water and related land resources. This law also provides guidance for adoption and approval of water and related land resources plans. Members of the IDWC are the Governor, the State Engineer (who serves as the chairman), the Attorney General's office, the State Department of Agriculture, the Department of Economic Planning and Development, the Department of Environmental Quality, the Game and Fish Commission, the Geological Survey of Wyoming, the Wyoming Highway Department, the Wyoming Recreation Commission, the Agricultural Extension Service of the University of Wyoming, the Director of the Wyoming Water Resources Research Institute, and the State Land Commission. Most of these agencies, if not all, will play important roles in carrying out water quality management under Section 208. As a result, the IDWC could be a very effective focal point at the State level for providing some 208 or related functions, especially as a coordinating agency.

Department of Economic Planning and Development

The Wyoming Department of Economic Planning and Development (DEPAD) influences water quality by planning for and directing the development of water resources, industry, and mining in the State. DEPAD evaluates the engineering and economic feasibility of water resources development projects, and makes recommendations to the Wyoming Farm Loan Board for approval of loans not to exceed $150,000. It prepares plans and specifications for industrial development and attracts new industry to the State. Finally, it prepares State legislation pertaining to the mineral resources of the State.

Industrial Siting Council

Facilities that fall under the Plant Siting Act of Wyoming include synthetic fuel conversion plants, such as those for oil shale or coal gasification. Other types of facilities involved are electrical generating facilities, yellowcake refining, and, in general, any plant costing more than $50 million to build. One requirement for plant siting is to consider water quality effects of the construction. DEQ can recommend certain water quality conditions be included in the industrial siting permit, but the State Engineer's final opinion is binding on the Industrial Siting Council for the purposes of issuing an industrial siting permit. The administration of the Plant Siting Act takes place through the Office of Industrial Siting Administration.

The Plant Siting Act can be effective only on new sites, not on pre-existing facilities. Pre-existing facilities do have to file annual reports on their 5-year plans for growth and development, however. These reports are required to be kept confidential by the Plant Siting Council and can only be released with the permission of the applicant. The information from these 5-year planning reports is therefore not available to this study without specific industry permission.

Recreation Commission

The Wyoming Recreation Commission (WRC) administers Big Sandy Recreation Area. It also administers the Land and Water Conservation Fund through which financial assistance is provided to tax-based legal entities for the development of outdoor recreation areas and facilities.

AUTHORITIES AT FEDERAL LEVEL

United States Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) grants funds to carry out 208 planning as well as treatment facility planning, design, and construction for municipal types of operations. The role of EPA in the control of other pollution source types can be quite inclusive and is generally carried out through permit type programs such as those in effect for industrial and municipal discharges and those being considered for agricultural discharges. EPA is, at the Federal level, most important to water quality planning and management as a catalyst to get other Federal, State and local agencies involved and acting.

Farmers Home Administration

Programs of the Farmers Home Administration (FMHA) have traditionally been oriented toward the rural portions of America. They provide credit for specific types of farmers who cannot get the financing they need at reasonable rates and terms elsewhere. The objective of the loans is to encourage and facilitate the improvement, protection, and proper use of farmland.

Soil Conservation Service

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has traditionally played a role of providing technical assistance to land users in carrying out locally adopted soil and water conservation programs. SCS works through local conservation districts to provide planning and application assistance for implementing programs, as for example under the cooperative agreements mentioned earlier.

Funds are available on a cost-share basis for watershed protection, flood prevention, erosion control, and public water-based recreation. Funds are authorized under the Watershed and Flood Prevention Act (PL-566) and the Resource Conservation and Development Program.

Agricultural Stabilization and Conservation Service

The Agricultural Stabilization and Conservation Service (ASCS) of the United States Department of Agriculture seeks to improve or protect the soil and to provide for the conservation or safe disposal of water. These goals are accomplished by farmers and ranchers with financial assistance from ASCS and technical assistance from SCS and the Forest Service. Emphasis is given to enduring practices needed to solve serious problems, as identified by county committees.

Forest Service

Perhaps the most important function of the Forest Service within the study area is the administration of the Flaming Gorge National Recreation Area. It administers this land under the multiple use concept to provide timber, forage, recreation, wildlife habitat, and watershed protection.

There are very little forest and timber activities within the planning area. Most of these activities are now on public lands. The Forest Service is responsible for administering good conservation practices related to timber operations. DEQ, by monitoring water quality, determine when there are impacts from timber activities on water quality. These should be addressed by the Forest Service on National Forest lands and by the Wyoming State Forester on non-federal forested lands.

The Forest Service is now carrying out a barometer watershed project in the drainages of Gilbert Creek, East Fork, and Smiths Fork to extensively monitor a watershed prior to any lumbering activity so that when harvests are carried out the impacts can be compared with a baseline condition. This information will be useful for predicting impacts of future lumbering activities in similar areas.

Bureau of Land Management

The Bureau of Land Management (BLM) manages all of the National Resource Lands in the study area. It is responsible for the proper management of these lands, which includes consideration of water quality impacts as well as soil conservation and other features. The Bureau establishes regulations and issues use authorizations (licenses, permits, grants, leases, etc.) to National Resource Land users. It also constructs and maintains improvements and facilities on the National Resource Lands.

Bureau of Reclamation

The development of water resources for use in irrigation and other activities is the primary responsibility of the Bureau of Reclamation. Some of the Bureau's projects within the study area are the Lyman project, the Seedskadee project, the Flaming Gorge project, the Eden project, and the Sublette and Big Sandy investigations. Fontenelle Reservoir is part of the Seedskadee project. Thus, the impact of Bureau of Reclamation activities may be widespread in terms of both existing and future water quality situations.

A new program of the Bureau of Reclamation is management of recreational facilities at various reservoirs in the area. Fontenelle Reservoir was the Bureau's first attempt in the nation to implement the new program. This activity started 4 years ago when the National Park Service wanted to drop its responsibility at Fontenelle. Bureau personnel expect the program to expand.

Youth Conservation Corps camps are to be part of this recreation program, and activities at these camps could be directed toward streamside management. In addition, the Bureau has the potential as a public education tool through installation of interpretative centers at the various recreational sites that it manages.

United States Geological Survey

The primary role of the United States Geological Survey (USGS) is to collect and file data. The Conservation Division sets standards for oil and gas activities which include water quality considerations. Generally, however, this agency does not promulgate or enforce standards nor does it take on responsibility for any management or abatement actions relating to water quality. It does perform surveys and studies of water quality and quantity situations, presumably at the request and direction of appropriate Federal or State agencies.

Corps of Engineers

The Corps is mainly involved in flood control projects, but may also be concerned with streambank salinity problems. Indirectly, then, its activities can relate to water quality issues.

The Corps is responsible for Section 404 of PL 92-500. This section calls for dredge and fill permits, which are administered by the Corps. Thus, anyone seeking to change stream courses must go through the Corps of Engineers for a permit. These permits may also apply to various agricultural activities. DEQ must certify "404" permits in the state of Wyoming. The new amendements to PL 92-500 allow DEQ to assume the dredge-and-fill program, so it is unclear if this program will be under the Corps or DEQ in the future.

SPECIFIC AUTHORITIES REQUIRED OF MANAGEMENT AGENCIES UNDER 208(1)

The management plan must develop a management system capable of implementing the areawide 208 Plan. The management system requires the following basic capabilities in order to be feasible, reliable, and implementable:

- Adequate legal authority to carry out the actions required
- Institutional capability based on a practicable, effective, and coordinated institutional structure
- Financial capabilities appropriate to the water quality needs and the specific plans produced in the technical section of the 208 study

These capabilities rest on certain authorities. The specific authorities required are dependent upon the particular role carried out by a specific agency, but in general a list of required authorities can be completed that relate to 208-type activities. This list of 31 types of authority is given on Table 7-2 according to the six major functions identified earlier for implementing a 208 Plan. These authorities are required by Section 208(b)(2) and 208(c)(2) of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). Other sections of the same act may also call for the same authority or functions.

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(1) Information pertaining to required legal authorities was drawn from material prepared by Linton and Company, Inc., for the Toledo, Ohio, area 208 program.

Table 7-2

AUTHORITIES REQUIRED TO PERFORM 208 MANAGEMENT FUNCTIONS

		Plan	Finance	Administer, Oversee Activities	Regulate, Enforce, Monitor	Construct, Enact	Operate
1.	Spend money to construct and manage treatment plants		x	x		x	x
2.	Contract work to others	x	x	x	x	x	x
3	Employ people	x	x	x	x	x	x
4.	Insure facilities					x	x
5.	Acquire, hold, or dispose of real property					x	x
6.	Engage in research	x			x	x	x
7.	Receive or accept money	x	x	x	x	x	x
8.	Make loans or grants	x	x				
9.	Contract with State or Federal agencies	x	x	x		x	
10.	Assess users for treatment costs		x	x		x	x
11.	Enter industrial cost recovery contract		x	x		x	x
12.	Reassign unused industrial discharge rights			x			x
13.	Monitor treatment operations			x	x		x
14.	Issue general obligation bonds		x				
15.	Issue revenue bonds		x				
16.	Issue anticipatory bonds		x				
17.	Issue anticipatory notes		x				
18.	Invest money elswhere		x				x
19.	Contract for private financing	x	x	x			
20.	Require local agencies or industries to participate		x	x	x		
21.	Charge participants	x	x	x			
22.	Refuse service non-compliance with plan			x	x		
23.	Disallow expansion for plan non-compliance			x	x		
24.	Impose other sanctions for plan non-compliance	x		x	x		x
25.	Refuse industrial wastes not meeting requirements			x			x
26.	Condemn land for public use			x		x	
27.	Develop and/or impose land use controls			x		x	
28.	Promulgate pretreatment and effluent standards	x		x	x		x
29.	Issue permits, as a precondition to treatment			x	x		x
30.	Enforce rules, punish violators	x	x	x			x
31.	Engage in planning beyond land use	x		x			

In addition to the six major functions and associated required authorities, management agencies should also be set up for particular roles in terms of (1) their geographical jurisdiction or the means to acquire such jurisdiction over applicable portions of the waste treatment management area and (2) their accountability to the electorate. All these factors are important in evaluating the feasibility of a proposed management structure for implementing a 208 plan.

Table 7-3 indicates what legal authorities are associated with the agencies mentioned earlier.

CONCLUSIONS

Numerous agencies are involved with all aspects of water quality management, though not necessarily in a coherent way. Sufficient agency coverage may well exist, then, to implement the various actions this 208 plan will call for. Specific agency assignments for specific control actions will be discussed in Chapters 8, 9, and 10. Chapter 11 gives the same information for the recommended plan.

AGENCY AUTHORITIES

	AGENCIES[1]																								
	FEDERAL										STATE								OTHER						
	EPA	FWHA	ASCS	SCS	COE	BLM	BR	NPS	FS	USGS	DEPAD	DEQ	SE	WCC	WRC	IDWC	WPSC	SF	SWWQPA	COUNTIES (2)	TOWNS(2) CITIES	LCD'S	FARMERS	HOME OWNERS	CRSF
1. SPEND MONEY TO CONSTRUCT AND MANAGE TREATMENT PLANTS			●		●			●	●		●								?	●	●				
2. CONTRACT WORK TO OTHERS	●	●		●	●	●	●	●	●	●	●	●	●	?	?		?	?	●	●	●	?	O	O	
3. EMPLOY PEOPLE	●	●	●	●	●	O	O	●	●	●	●	O	O	O	O		O	O	O	O	O	O	O	O	
4. INSURE FACILITIES	?	?	?		?			?	?		?								?	●	●	?	?	?	
5. REQUIRE OR HOLD PROPERTY	?	?	?		●	●	●	●	●	?	●	?	?	?	?			?	?	●	●	?	●	●	
6. ENGAGE IN RESEARCH	●	●			●	●	●	●	●	●		●	●	●	?		?	?	?	?	?	?	●	●	
7. RECEIVE OR ACCEPT MONEY	●	?		?	●	?	?	?	?	?	●	●	?	●	?		?	?	●	●	●	●	●	●	
8. MAKE LOANS OR GRANTS	●	●	●	●	●	?	?	?	?	?	●	●	?	?	?		?	?	?	?	?	?	●	●	
9. CONTRACT WITH STATE OR FEDERAL AGENCIES	●	●	?	●	●	●	●	●	●	●	●	●	●	●	?		?	O	●	●	●	●	●	●	
10. ASSESS USERS FOR TREATMENT COSTS	?				?	?	?	?	?		●			?					?	●	●	?			
11. ENTER INDUSTRIAL COST RECOVERY CONTRACT	?		●		?						●								?	●	●	?			
12. REASSIGN UNUSED INDUSTRIAL DISCHARGE RIGHTS	?				?						?	●							?	?	?				
13. MONITOR TREATMENT OPERATIONS	●	O			●						O	●	?				●	●	?	●	●	?			
14. ISSUE GENERAL OBLIGATION BONDS																			?	●	●	?			
15. ISSUE REVENUE BONDS											●								?	●	●	?			
16. ISSUE ANTICIPATORY BONDS											?								?	?	?	?			
17. ISSUE ANTICIPATORY NOTES											?								?	?	?	?			
18. INVEST MONEY ELSEWHERE	?	?	?	?		?	?	?	?	?	?		?	?	?		?		?	?	?	?			
19. CONTRACT FOR PRIVATE FINANCING	?	?									●						?		?	?	?	?			
20. REQUIRE LOCAL AGENCIES OR INDUSTRIES TO PARTICIPATE	●		●		●	●	●		●		●	●	●	?			●	●	?	?	?	?			
21. CHARGE PARTICIPANTS	●	●	●	●	●	●	●	●	●		●		?					?	?	●	●	?			
22. REFUSE SERVICE FOR PLAN NON-COMPLIANCE			●		●	●	?	●	●		O	?	?						●	●	●	?			
23. DISALLOW EXPANSION FOR PLAN NON-COMPLIANCE			?		●						O	●	?				●		●	●	●	?			
24. IMPOSE OTHER SANCTIONS FOR PLAN NON-COMPLIANCE	●		?		?	?	?	?	?		O	●	●				●	●	?	●	●	?			
25. REFUSE INDUSTRIAL WASTES NOT MEETING REQUIREMENTS					●						O								?	?	?	?			
26. CONDEMN LAND FOR PUBLIC USE						?					●				?				?	●	●				
27. DEVELOP AND/OR IMPOSE LAND USE CONTROLS		●				●	●	●	●		●	O	?	?	?		●	●	?	●	●	?			
28. PROMULGATE PRETREATMENT AND EFFLUENT STANDARDS	●				●						●	●					●		●	?	?	?			
29. ISSUE PERMITS AS A PRE-CONDITION TO TREATMENT	●				●		?				O	●					●	●	?	?	●	?			
30. ENFORCE RULES, PUNISH VIOLATORS	●		●		●	●	●	●	●		O	●	●	?	?		●	●	?	●	●	?			
31. ENGAGE IN PLANNING BEYOND LAND USE	●	?		●	●	●	●	?	●	●	●	●	O	?	?	●	?		●	●	●				●

(1) ALL AGENCY ABBREVIATIONS ARE IDENTIFIED ON TABLE 7-1, EXCEPT FOR IDWC (INTERDEPARTMENTAL WATER CONFERENCE) AND CRSF (COLORADO RIVER SALINITY CONTROL FORUM).

(2) INCLUDES JOINT POWER BOARDS.

LEGEND

● AUTHORITY EXPRESSED
O AUTHORITY IMPLIED
? AUTHORITY UNKNOWN
BLANK NO AUTHORITY

Chapter 8
CONTROLS FOR SALINITY

The overall direction of this technical report is (1) the identification of water quality problems and problem constituents, (2) the identification of contaminant sources, and (3) the development of management plans to control those sources. The first step was completed in Chapter 3 and Chapter 4. The most important conclusions arrived at in those two chapters with respect to salinity were:

- The level of total dissolved solids in the Green River from Big Sandy River to Flaming Gorge Reservoir has important economic consequences for industry
- The chloride, sulfate, and total dissolved solids criteria for livestock and wildlife watering are exceeded in Killpecker Creek
- The sulfate criterion for livestock and wildlife watering is exceeded in Upper Bitter Creek
- The sulfate criterion for public water supplies is exceeded in the Green River reach, in Flaming Gorge Reservoir, in the Lyman reach of the Blacks Fork, and in the Lower Hams Fork reach
- The level of total dissolved solids in the Green River reach has important economic consequences for public water supply users
- Practices in the study area which change salinity loads or concentrations in the Green River system have important economic consequences for water users on the Lower Colorado River

The second step, the identification of existing and future salinity sources, was completed in Chapter 5 and Chapter 6. Existing sources of salinity were identified in Chapter 5, while the impacts of future diversions and depletions were assessed in Chapter 6. The most important conclusions arrived at in these two chapters with respect to salinity were:

- Large salinity loads are generated in the Bridger Valley and the Big Sandy drainage
- Large loads are carried by the Green River into the study area
- Approximately half of the salinity load generated in the study area is attributed to natural ground water discharges, while most of the remaining salinity is delivered in irrigation return flows
- The contact zone (see Figure 5-17) is the geographic area where surface and subsurface activities have had and will continue to have the most impact on salinity

- The contact zone passes through the Bridger Valley and the Big Sandy drainage
- The area of Mancos-type shales in the Bitter Creek drainage has the potential to generate large salinity loadings if recharge sources such as reservoirs or irrigation are provided.
- The coal export scenario predicts little change in salinity concentrations within the study area or downstream, while the energy export scenario predicts little change in salinity concentrations within the study area but a significant increase downstream
- Diversions from Fontenelle Reservoir and Big Sandy Reservoir will significantly change salinity concentrations in the Green River and downstream in the Colorado River

The final step is the development of a management plan to control salinity. This chapter will describe nine management options that address the control of salinity sources and the alleviation of salinity problems mentioned above. Chapter 11 presents a combination of the nine options which represents the salinity management plan recommended by the staff of the Southwestern Wyoming Water Quality Planning Association (SWWQPA) and its consultants.

The salinity management options are listed on Table 8-1 in the order in which they appear in this chapter. The order is not meant to imply any preference. A consistent format has been used in the presentation of each option. The format includes a description of the control measure and the problem towards which it is directed and, where appropriate, how effective the option might be, its costs and benefits, who should carry it out, and what its environmental and social impacts are.

Each option has been developed to address one or more of the salinity problems listed on Table 3-8 and one or more of the salinity sources listed on Table 5-16. The relationship between salinity problems, sources, and management options is shown on Table 8-2.

Table 8-1

SALINITY MANAGEMENT OPTIONS

1. The Big Sandy River Unit study.
2. Sprinkler irrigation in Bridger Valley.
3. Improvement of irrigation efficiencies in Bridger Valley and Big Sandy area through better timing of irrigations.
4. Salinity control in Sublette County.
5. Interception of ground water in the Big Sandy recharge area.
6. No action.
7. Salinity standards.
8. Control of water resources development and drilling activities in areas where salts can be mobilized.
9. Consideration of diversion and depletion impacts.

Table 8-2

PRINCIPAL EXISTING SALINITY SOURCES AND MANAGEMENT OPTIONS

Use	Constituent	Reach with Water Quality Problem	Source	Location	Management Option
Industrial Water Supply	Total Dissolved Solids	Green River, Big Island Reach to Green River Arm	Irrigation return flows Natural ground water discharges Outside study area	Contact zone, Big Sandy drainage Contact zone, Big Sandy drainage Sublette County	1, 3, 4, 5, 6, 7, 8, 9
		Blacks Fork Arm	Irrigation return flows Natural ground water discharges	Contact zone, Bridger Valley Contact zone, Bridger Valley	2, 3, 6, 7
		Middle Hams Fork	Natural ground water discharges	Bridger formation, Hams Fork drainage	6, 7, 8
Livestock and Wildlife Watering	Chloride	Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage	6, 7, 8
	Sulfate	Upper Bitter Creek	Natural ground water discharges	Mancos-type shales, Bitter Creek drainage	6, 7, 8
		Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage	6, 7, 8
	Total Dissolved Solids	Killpecker Creek	Natural ground water discharges	Mancos-type shales, Killpecker Creek drainage	6, 7, 8
Public Water Supply	Sulfate	Green River	Irrigation return flows Natural ground water discharges	Contact zone, Big Sandy drainage Contact zone, Big Sandy drainage	1, 3, 5, 6, 7, 8, 9
		Flaming Gorge Reservoir	Irrigation return flows	Contact zone, Big Sandy drainage and Bridger Valley	1, 2, 3, 5, 6, 7, 8, 9
			Natural ground water discharges	Contact zone, Big Sandy drainage and Bridger Valley	
		Lyman Reach-Blacks Fork	Irrigation return flows Natural ground water discharges	Contact zone, Bridger Valley Contact zone, Bridger Valley	2, 3, 6, 7
		Lower Hams Fork	Natural ground water discharges	Bridger formation, Hams Fork drainage	6, 7, 8
	Total Dissolved Solids	Green River	Irrigation return flows Natural ground water discharges Outside study area	Contact zone, Big Sandy drainage Contact zone, Big Sandy drainage Sublette County	1, 3, 4, 5, 6, 7, 8, 9

OPTION 1
BIG SANDY RIVER UNIT STUDY

PROBLEM STATEMENT

The Big Sandy River Unit is one of the units to be studied under the Colorado River Basin Salinity Control Program. The goal of this program is to maintain 1972 salinity levels in the Lower Colorado River Basin. The Big Sandy River delivers concentrated salinity loads to the Lower Basin by way of the Green River.

MANAGEMENT ACTION

Assistance programs, research projects, and demonstration projects are presently being carried out in the area by the following agencies: Bureau of Reclamation, Soil Conservation Service, Environmental Protection Agency, Department of Agriculture, Office of Water Resources Research, University of Wyoming. The 208 Plan supports the efforts of these agencies because many of the proposed salinity control measures are likely to have favorable benefit-cost ratios not only for the Colorado River Basin, but also for the study area.

The 208 Plan recommends that those salinity control options that pertain to the Big Sandy area and that are included in the recommended plan in Chapter 11 be studied closely under the Colorado River Salinity Control Program. These options include improved irrigation efficiencies, restricted drilling near the contact zone between the Bridger and Wilkins Peak Formation, and interception of ground water at Big Sandy Reservoir.

OPTION 2
SPRINKLER IRRIGATION IN BRIDGER VALLEY

PROBLEM STATEMENT

Salinity has been shown to be a costly water quality problem to water users inside and outside the study area. Irrigation return flows are a major contributor to the salinity loads generated within the study area. For example, irrigation return flows from the Bridger Valley are estimated to deliver 125,000 tons of salt per year to Blacks Fork. This loading is equal to 38 percent of the total salinity load generated in the Blacks Fork drainage basin.

MANAGEMENT ACTION

The management action would involve a study of the feasibility of converting irrigation in Bridger Valley from wild flooding to sprinklers. Bridger Valley has been selected because salt loads from irrigation return flows are estimated to be very large, and because little study has been made of salinity controls in Bridger Valley.

The goal of the study should be a prediction of salinity reduction achievable by a change in irrigation practice to sprinkler irrigation. Good information is available on the costs and benefits to farmers of sprinkler irrigation from the Wyoming Agricultural Extension Service and from experiences of farmers in Star Valley, which is located in the study area along the Salt River. However, data are not available for an accurate prediction of salinity reduction from a conversion to sprinkler irrigation. Experiences in Riverton and Star Valley indicate that efficiency of sprinkler irrigation is greater than efficiency of wild flood irrigation and that salinity reductions in irrigation return flows are likely.

Two types of studies may be initiated. The first would be a pilot project in the Bridger Valley. The second would be a comparison of salinity loads in the Salt River before and after irrigation was changed to sprinklers. Salinity data exist before sprinkler irrigation, but salinity monitoring was abandoned in the Salt River after sprinkler irrigation. Several years of monitoring may indicate whether sprinkler irrigation has made any demonstrable changes in salinity loads carried by the Salt River.

EXPECTED SALINITY REDUCTION

Rough estimates of salinity reductions achievable by conversion to sprinkler irrigation in Bridger Valley are impressive. One reference (Wyoming Agricultural Experiment Station, 1974) assumed a 75 percent irrigation efficiency with sprinkler irrigation. The present irrigation efficiency at the Eden-Farson project, where flood irrigation is used as in Bridger Valley, is 33 percent. A second estimate of increased efficiencies with sprinkler irrigation was made by comparing the amount of water applied to land in 1976 in the Eden-Farson area and in the Riverton area where sprinkler irrigation is used. Approximately 25 percent less water was applied per acre at Riverton than at Eden-Farson. This analysis of increased irrigation efficiencies is tenuous, and more effort should be made to do on-site studies necessary to develop reliable estimates of water savings.

Salt load reductions can be calculated from the estimates of increased efficiencies given above. If it is assumed that alfalfa crops in Bridger Valley need 20 inches of water from irrigation, the amount of irrigation water diverted but not used by the crop is decreased by 43-82 percent with a conversion from wild flood irrigation to sprinkler irrigation. The diverted water which is not used by the crop is assumed to percolate through the soil and rock and to pick up salts. According to the method used in Chapter 5 to calculate salinity loads from irrigation return flows, a 43-82 percent reduction in percolating water would produce a 43-82 percent reduction in the salt loads carried by irrigation return flows. For Bridger Valley, this reduction translates to 55,000-103,000 fewer tons of salt per year delivered by irrigation return flows. This loading reduction constitutes a 17-31 percent reduction in salt loads carried by Blacks Fork to the Colorado River system.

EXPECTED COST

The cost of the feasibility study is difficult to determine. A rough estimate is $50,000 to $150,000.

The cost for conversion to sprinkler irrigation has been obtained from "Economic Appraisal of Irrigation Systems for the Green River Basin, Wyoming." The fixed costs for conversion are $12-27 per acre per year (in 1977 dollars) and variable costs for conversion are $28-44 per acre per year. The total annual cost for the Bridger Valley would be $2.6-4.7 million. These costs are borne by the farmers unless State or Federal grants are involved.

BENEFITS AND TO WHOM

Conversion to sprinklers is not likely to be a profitable venture for farmers in Bridger Valley. The major benefit to farmers in Star Valley from the conversion has been increased yields of crops to feed dairy herds. At present, hay and alfalfa constitute most of the crops in Bridger Valley. Increased yields of these crops in the Bridger Valley would produce relatively small benefits because of their low market value. Therefore, unless farmers in Bridger Valley convert to cash crops, they will realize few benefits by converting from wild flood irrigation to sprinkler irrigation. One reference (Agricultural Experiment Station, 1974) estimated that the alfalfa stand would have to yield 4.5 tons per acre before sprinkler irrigation would become profitable for the farmer. Present alfalfa yields in the Bridger Valley average 1.5 to 2 tons per acre.

Given the estimates of expected salinity reduction, the conversion would be of great value to industry in the study area and to users of water from the Lower Colorado River system. The benefits to industry in the study area are estimated to range from $585,000 to $1,065,000 per year, with an average annual benefit of $825,000. Benefits to users outside the study area are estimated to range from $1.7 to $3.2 million per year, with an average annual benefit of $2.5 million. The basis for making such estimates was given in Chapter 4.

This option may have several additional benefits which are difficult to quantify. One type of benefit concerns water conservation. Water conserved under this option could be used to alleviate late-season water shortages, to supply other uses such as public water supplies, or to irrigate more acres. In Bridger Valley, these benefits would probably be small compared to those estimated above for industry and users outside the study area. The Stateline Project has been designed and constructed to relieve most late-season irrigation water shortages and supply enough water for domestic users. Irrigation of more land, particularly in the contact zone through Bridger Valley, would offset the benefits of salt loading reductions achievable under this option.

A second possible benefit is the reduction in the number of failing septic tanks. This benefit might result from a lower ground water table, which in turn would be brought about by the water conservation practices called for under this resolution. Like the benefits of water conservation itself, however, the benefits of a lower ground water table are difficult to predict and quantify.

The benefit-cost ratio for the study area is 0.12-0.41, if the two types of benefits which are difficult to quantify are not included. The benefit-cost ratio including benefits to those outside the study area is 0.49-1.64. Therefore, on the basis of quantifiable benefits and costs, this option is not recommended to be taken up by the State unless additional benefits can be gained by the farmers by a change from forage crops to cash crops. The benefit-cost ratio at the basinwide level may be greater than one, and therefore the option may be worthy of further study by the Colorado River Salinity Control Forum.

WHO PAYS

If a feasibility study is initiated, it would probably be done under the Colorado River Basin Salinity Control Project. Funding for the study itself could come from the budget of the project. If a conversion to sprinkler irrigation is determined to be feasible, the sprinkler systems could be funded 75 percent by the Colorado River Basin Salinity Control Project and 25 percent by local funds.

Several sources of funding are available at the local level. Water conservation districts are authorized to fix the price of water (WSA 41-91). The districts could purchase the sprinkler systems and pay them off over time through a charge for water from the Stateline Project. State loans are available through the issuance of bonds by the Farm Loan Board or through the Revolving Funds of the Department of Economic Planning and Development. Other sources of loans include the Federal Land Bank and the Farmers Home Administration. Cost-sharing arrangements are available to farmers through the Great Plains Conservation Program, handled by SCS, or through the Rural Environmental Assistance Program and the Agricultural Conservation Projects (ACP) Program, handled by the Agricultural Stabilization and Conservation Service. Culver funds (Amendment 208-J) may also become available, particularly if this project receives designation as a Model Implementation Project.

WHO ACTS

An unfavorable benefit-cost ratio in the study area has been calculated for this management option. For the basin as a whole, it is unclear if the option has a favorable or unfavorable ratio. One of two paths may be taken. The option may be dropped, even though the benefit-cost determination is based on weak information. The alternative is to strengthen the benefit-cost calculation by performing a feasibility study. If this option is pursued, a feasibility analysis of conversion from forage to cash crops in Bridger Valley should also be made. This conversion may affect substantial benefits to the farmers of Bridger Valley, who are the group bearing the costs incurred under this option.

If a feasibility study is initiated, the authorization would probably come from the Colorado River Basin Salinity Control Forum. Both State and Federal agencies could be involved. The State agencies involved could include the Department of Environmental Quality, the Agricultural Extension Service, and the Water Resources Research Institute. Federal agencies could include the Environmental Protection Agency, the Bureau of Reclamation, the Soil Conservation Service, and the Agricultural Research Service.

ENVIRONMENTAL AND SOCIAL IMPACTS

The proposed feasibility study would have no environmental and social impacts. The actions recommended in the feasibility study may have some impacts. These would be covered in the feasibility study. One possibly severe social impact of this option is that sprinkler irrigation would require full-time farming or the hiring of irrigators. At present, farming is generally a part-time occupation in Bridger Valley.

OPTION 3
IMPROVEMENT OF IRRIGATION EFFICIENCIES THROUGH BETTER TIMING OF IRRIGATIONS

PROBLEM STATEMENT

Irrigation return flows produce an estimated 37 percent of the total salt load generated within the study area. Control of the loadings from irrigation return flows can reduce salinity and reduce the costs associated with them.

At present, irrigation of land in the two largest salt producing areas, Bridger Valley and the Eden-Farson area, is approximately equally spaced in time, even though water requirements of a crop change considerably from spring to summer to fall. This is a concern because when more water is applied to the land than is lost through evapotranspiration, the excess can percolate through the soil to come in contact with the saline formations so prevalent in the two areas mentioned. The salts dissolve and leach to surface waters. An excess of water during the early and late parts of the season can raise instream salinity levels.

MANAGEMENT ACTION

One method for controlling these loadings is to continue to use flood irrigation but to improve irrigation efficiencies on the farm. A higher efficiency results in less water percolating through saline soils and rocks. A management option to increase efficiencies on the farm is to space irrigations in spring and fall at greater intervals and to apply less water at these times of year in order to match water applied to the land with the lower water requirements of crops in spring and fall.

The management option would be a voluntary action taken by the individual farmers through conservation plans developed with the local conservation district. The Soil Conservation Service (SCS) and the Agricultural Research Service (ARS) would assist the farmers in the determination of water requirements for crops. The Cooperative Extension Service could explain the reasons for salinity control and the potential benefits and costs associated with this management option.

Experts from the Agricultural Experiment Stations could also be available to answer questions concerning irrigation efficiencies. More effort should also be made by those at the Station and SCS to improve the distribution of information from the experimental farms to the individual farmers and to promote the conversion of successful experiments to practice on private farms.

An excellent educational and research tool is the demonstration project. As part of the action described here, SCS and the local conservation districts should seek to establish at least one demonstration project in each area so farmers can learn first hand what is involved. Implementing success for conversion to sprinkler irrigation in Star Valley is largely attributed to having some early projects for other farmers to see and learn from.

EXPECTED CONTAMINANT REDUCTION

Figure 8-1 shows the irrigation efficiencies in 1963 on a 97.3-acre irrigated pasture in the Eden-Farson area. Irrigation efficiencies were relatively constant during the middle of the irrigation season, but significantly lower at the start and the end. It is assumed that the efficiency at these two times of year could be improved to 34 percent by better spacing of irrigation. The improved efficiency would result in a 17 percent reduction in water needs. According to the method used in Chapter 5 to calculate salt loads in irrigation return flows, the 17 percent reduction in water use would mean a 17 percent reduction in salt loads. The salt load reduction in the Eden-Farson area would be 12,000 to 23,000 tons per year, depending on which estimate is used of existing salt loads in irrigation flows from that area. The estimated salt load reduction from the Bridger Valley would be 22,000 tons per year.

Under this management option, the salinity concentrations at the station designated Green River near Green River would be reduced 1.8-3.5 percent. Salinity concentrations at the station designated Blacks Fork near Little America would be reduced 6.7 percent.

EXPECTED COST

Almost all farmers in the Eden-Farson area and Bridger Valley have second jobs off the farm; consequently, they would have to hire irrigators to open and close gates while they are at work. It is estimated that approximately 20 to 40 irrigators would be required in the Eden-Farson area at an annual cost to the farmers of $150,000 to $300,000; approximately 70 to 140 irrigators would be required in Bridger Valley at an annual cost of $550,000 to $1,100,000. Costs will be incurred by SCS and the Cooperative Extension Service because of the need for better dissemination of information and supervision of irrigation practices. These costs would be in the form of additional pamphlets and additional mandays spent in the field demonstrating the management option and explaining the benefits. These costs are probably negligible compared to the expense for irrigators, however.

BENEFITS AND TO WHOM

Benefits from this management option are shown on Table 8-3. More benefits occur outside the study area than within it; however, benefits within the study area are substantial. Control of salinity in the Eden-Farson area has greater benefits to users in the study area than control of salinity in Bridger Valley. Those who benefit in the study area include industry and domestic users of surface water.

The Rock Springs-Green River area could also benefit from the reduction of sulfate concentrations in the Green River reach which may be attained under this option. The salt load from the Big Sandy River is predominantly sodium sulfate. Therefore, salinity control in the Big Sandy is also likely to control sulfate and bring about a reduction in sulfate concentrations downstream.

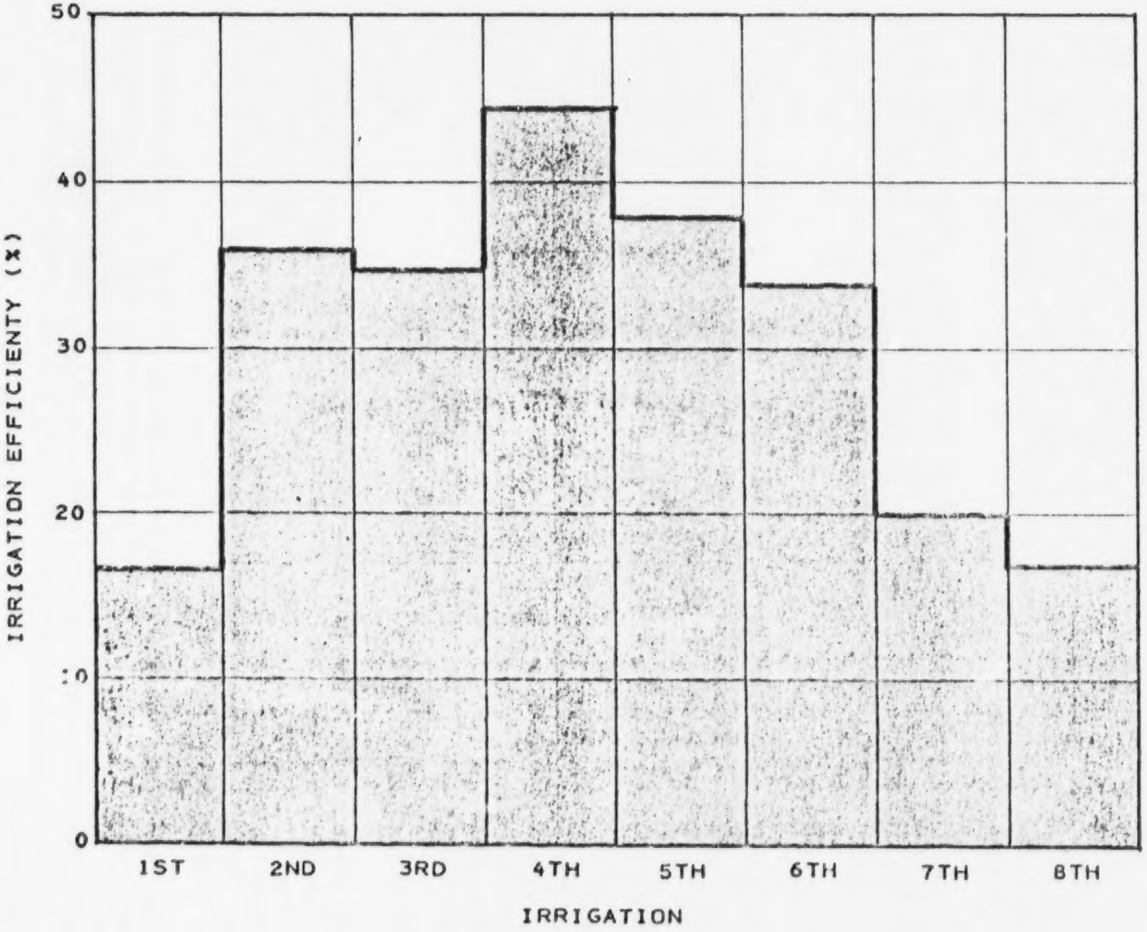

FIGURE 8-1

IRRIGATION EFFICIENCY ON
A TEST PLOT IN THE EDEN-FARSON AREA

Table 8-3

BENEFITS FROM SALINITY REDUCTION BY IMPROVED IRRIGATION EFFICIENCY

	Benefits (Annual)		
User Group	Present Day	Coal Export Scenario (1)	Energy Export Scenario (1)
Control in Eden-Farson Area--			
Industry	$ 100,000	$320,000	$520,000
Domestic	5,000	6,500	9,800
Outside Study Area	550,000	--	--
Control in Bridger Valley--			
Industry	0	0	230,000
Domestic	0	0	0
Outside Study Area	690,000	--	--
Control in Both Areas--			
Industry	100,000	320,000	750,000
Domestic	5,000	6,500	9,800
Outside Study Area	1,240,000	--	--

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(1) Estimates of benefits include influence of population increases under the scenario, but not of depletions. See Chapter 6 for discussion of future development scenarios.

Agriculture in the study area may also benefit from this management option through a decreased demand for water. Water shortages occur on the average of 1 in 4 years in the Eden-Farson area and almost every year in Bridger Valley. In these years of water shortages, crop production may increase in both areas because of more efficient use of the limited water supply stored in the reservoirs.

Residents of the two areas may also benefit from a decrease in the number of failing septic tanks, brought about by a lowering of the ground water table. These benefits are difficult to quantify, however, because the number of failures attributable to a high ground water table is unknown.

Benefit-cost ratios are shown on Table 8-4. Only the reasonably quantifiable benefits have been included. Irrigation management cannot be justified in the Bridger Valley on a benefit-cost basis, even if benefits outside the study area are considered. The benefit-cost ratio is favorable in the Eden-Farson area, however, if benefits to users outside the study area are included. The benefit-cost ratio for both areas combined is also favorable if benefits to users outside the study area are included.

WHO PAYS

As mentioned above, almost all farmers in both the Eden-Farson area and Bridger Valley will have to hire irrigators in order to manage the use of irrigation water. Under the present system, these costs would be borne by the farmers. Federal and State assistance programs are aimed at relieving the burdens on farmers of capital improvements. Operation and maintenance costs are borne completely by the farmer.

Because this option is designed as a voluntary action, there is almost no chance that it will be instituted unless some of the benefits to downstream users are passed back to the farmers who bear the costs of salinity control. This transfer of benefits could be accomplished through one of three Federal programs. First, the Agricultural Conservation Program provides 50 to 75 percent of the cost of conservation practices that meet special conservation needs. The U.S. Department of Agriculture is authorized to provide funds through this program under the Soil Conservation and Domestic Allotment Act of 1936 (PL 74-46). A second means of returning benefits of salinity control to the farmers is through the Lower Basin Salinity Control Fund, administered by the Bureau of Reclamation. These funds are raised by increased power rates on Lower Basin users. The final funding source would be a 208 continuing grant.

WHO ACTS

This management alternative is designed to be a voluntary action of the individual farmers through local conservation districts with assistance from SCS. Because of the voluntary nature of this alternative and because the benefits of this alternative to the farmers are small, the likelihood of implementing it on a widespread scale may be low unless some agency takes specific action. The local conservation districts would be the most appropriate agency to locally carry out this action. The local conservation

Table 8-4

BENEFIT-COST RATIO FOR CONTROL OF SALT LOADS THROUGH IRRIGATION MANAGEMENT

	Benefit-Cost Ratio	
Area of Control	Study Area Only	Entire Basin
Eden-Farson	0.4-0.7	2.2-4.4
Bridger Valley	0	0.6-1.3
Eden-Farson and Bridger Valley	0.1-0.2	1.0-1.9

districts are authorized under WSA 11-245(c) to conduct demonstration projects to conserve water. This option may fall under this type of project. If the farmers see benefits from the demonstration projects, they may implement this option voluntarily. This approach worked for sprinkler irrigation in Star Valley. If this option does not work on a voluntary basis, the irrigation management recommended in this option could be made mandatory by the irrigation districts. These districts are authorized under WSA 41-285 to make rules and regulations for the use of water on their lands. The districts would probably hire the irrigators if this option were made mandatory. A mandatory program would probably be difficult to implement given the conservative political climate in the area.

If this option is adopted by SWWQPA, there would be a requirement for the local conservation districts to carry on the education work, although the program would be voluntary for the individual farmers. It is recommended that the Wyoming Conservation Commission and local conservation districts become the nonpoint source management agency on a local and statewide basis for agricultural activities pursuant to 40 CFR 131.11(o) and WSA 11-238.

ENVIRONMENTAL AND SOCIAL IMPACTS

There are no detrimental environmental impacts associated with this management option. The social impacts of this option are small if the option is voluntary. The social impacts would be much greater if the option were not voluntary, because the farmers would be forced to drop their second jobs or hire irrigators.

OPTION 4
STUDY POTENTIAL CONTROLS FOR SALINITY IN SUBLETTE COUNTY

PROBLEM STATEMENT

Of the salinity leaving Wyoming via the Green River system, approximately 26 percent enters from Sublette County and the remaining 74 percent is generated within the study area. Any salinity control program within the study area can be at most 74 percent effective in reducing salinity levels in the Green River as it leaves Wyoming.

Sublette County is not included in this 208 study, and the priority for funding 208 studies in Sublette County under the State's nondesignated area program is fifth out of six areas. Overall, the Sublette County study ranks twelfth on the list of projects for the PY-1978 Wyoming Water Pollution Control Program Plan. Therefore, funding for the county is unlikely in the near future. The salt load from Sublette County is predominantly calcium bicarbonate, which causes hardness in the water and raises water treatment costs for industry and domestic users downstream. Approximately 50 percent of the calcium reaching Flaming Gorge Reservoir from the Green River originates in Sublette County.

MANAGEMENT ACTION

The State DEQ should be encouraged to include consideration of salinity generated in Sublette County as an important factor in setting priorities for future funding of 208 studies in nondesignated areas of the State.

EXPECTED CONTAMINANT REDUCTION

Salinity reduction resulting from studies in Sublette County is assumed to be on the same order of magnitude as might be expected from this study area. That reduction would specifically be in the range of 5-20 percent of the total salinity loads.

EXPECTED COSTS

The cost of making salinity studies in Sublette County could be as little as $20,000 for a fairly cursory study to as much as $200,000 if extensive water quality simulation modeling were undertaken.

BENEFITS AND TO WHOM

The benefits of studying salinity in Sublette County are to equalize the pressure on people in the Green River Basin for salinity control. Without such studies, the pressure is more likely to be on the residents and water users of Sweetwater County rather than on those in Sublette County.

If the studies were to result in actions to reduce salinity levels, the benefits would accrue to all water users within Sweetwater County as well as downstream users outside the study area.

WHO PAYS

If studies of Sublette County were undertaken as part of 208 planning, the Federal Government would provide 75 percent of the cost. Additional costs beyond those that might be available from Federal sources would be borne by residents in Wyoming and, to some extent, by residents in Sublette County.

WHO ACTS

As part of its 208 Plan, the Southwestern Wyoming Water Quality Planning Association encourages the State to include in the statewide plan the necessary studies in Sublette County. The State would then have to carry out the studies or contract with Sublette County and/or outside contractors to do the work.

ENVIRONMENTAL AND SOCIAL IMPACTS

Possible environmental impacts of studies of Sublette County might be the eventual reduction of salinity in the Green River system.

A potential social impact of the studies is the possibility of Sublette County residents having to take action for the benefit of those downstream. A positive impact could be the awareness of Sweetwater County residents that all who are involved in the basin are included in considering controls.

If specific controls were developed as a result of the studies, the controls taken in Sublette County might not produce benefits to Sublette County residents, but would more likely produce benefits for downstream users in Sweetwater County and outside the State.

OPTION 5

INTERCEPTION OF GROUND WATER IN THE BIG SANDY RECHARGE AREA

PROBLEM STATEMENT

Critical geologic areas where additional recharge could have a major impact on salt loads in the rivers were indicated on Figure 5-17. As shown on the figure, Big Sandy Reservoir is located in one of these critical geologic areas. Seepage from the reservoir is recharging ground water in the critical area and may be an important contribution to the high salt loads found in seeps downstream in the Big Sandy River.

MANAGEMENT ACTION

The initial step under this option is a study of the feasibility of intercepting high quality ground water near the reservoir before it travels through the highly saline soils and bedrock downgradient. The intercepted ground water could be discharged from a series of barrier wells to the Big Sandy River. This action could have two beneficial effects. First, the amount of water which passes through the highly saline soils and bedrock downgradient from the reservoir would be reduced. Second, flow in the Big Sandy River would be augmented by high quality water from the wells; this additional flow would be available for beneficial use and for dilution of the highly saline water found in the Lower Big Sandy reach.

The feasibility study would be conducted through the Big Sandy River Unit project. This project is presently looking at controls primarily in the discharge areas. A more effective approach may be controls in the recharge areas, such as the one suggested in this option.

If this option were found feasible, it could be implemented through the Colorado River Basin Salinity Control Project.

EXPECTED CONTAMINANT REDUCTION

The expected contaminant reduction from this option is difficult to estimate because of a lack of information on the amount of seepage from the Big Sandy Reservoir and the amount of salt picked up by that seepage. Some very broad, highly speculative estimates are given in this section. These numbers would be more accurately defined in the feasibility study.

Big Sandy Reservoir is located in an area of highly permeable soils. The general soil type in the area is a Farson gravelly sandy loam. Flow velocities through these soils are estimated to range from 100 feet per year to 100,000 feet per year, which correspond to permeabilities of 100 to 100,000 gallons per day per square foot. Although flow-through rates are high for soils, little salinity is likely to be picked up by ground water flowing through these soils because of the small amount of leachable salts associated with gravelly loam and the short residence time of ground water in the soils before it is discharged to surface waters.

Most of the salt pickup by seepage water will result from leaching of the Bridger and Wilkins Peak Formations. These formations are primarily shales which have low permeabilities in the range of 1 x 10^{-2} to 1 x 10^{-4} gallons per day per square foot. These permeabilities correspond to flow rates of 1 x 10^{-2} to 1 x 10^{-4} feet per year. Within these formations, however, the shales are interbedded with tufaceous sandstones, algal limestones, and conglomerates. Permeabilities for these rocks are higher than those for shales and typically range from 0.01 to 10 gallons per day per square foot. These permeabilities correspond to flow velocities of 0.01 to 10 feet per year.

The permeability of bedrock under the reservoir may range from 0.0001 to 10 gallons per day per square foot, depending on the relative percentages of shale and more permeable materials. Given the broad range in permeabilities, seepage from Big Sandy Reservoir may be anywhere from 0.16 acre-foot per year (2 x 10^{-4} cfs) to 16,000 acre-feet per year (22 cfs). A more accurate estimate of seepage could be determined in the feasibility study by a detailed survey of the bedrock in the vicinity of the reservoir or a detailed analysis of the water budget for the reservoir.

Seeps in the Lower Big Sandy reach have salinity concentrations as high as 6,000 mg/l TDS. Surface geology indicates that some of this saline water may have originated as seepage from Big Sandy Reservoir, because the same geologic formations appear at the surface in the vicinity of the reservoir and in the vicinity of the seeps. If it is assumed that TDS concentrations in seepage from the reservoir average 2,500 mg/l, seepage may deliver as much as 55,000 tons of salt per year to the Green River system. However, if the bedrock permeability averages 1 x 10^{-4} gallons per day per square foot, seepage would deliver only 0.5 ton of salts per year.

EXPECTED COST

The expected cost of the feasibility study is estimated at $50,000 to $200,000. Costs of the project itself cannot be estimated until completion of the feasibility study.

BENEFITS AND TO WHOM

This option has the potential to reduce TDS and sulfate concentrations in the Big Sandy River and the Green River below the Big Sandy River. Those who would benefit include industrial and domestic water users in the study area and water users downstream and outside of the study area. Given a potential 55,000-ton-per-year reduction in salt loads, the potential benefits from this option total approximately $2 million per year. The benefits are allocated as follows: $15,000 per year to domestic water users; $300,000 per year to industry in the study area; and $1,700,000 per year to users outside the study area. These are potential benefits; in all likelihood, the salt reduction under this option will be somewhat less, and therefore the benefits will also be somewhat less.

Benefits may also be accrued by farmers in the Eden-Farson area. At present, irrigation water shortages occur 1 in 4 years. Sufficient water may be pumped from the barrier wells to the river to relieve these shortages.

WHO PAYS

Both the feasibility study and the project would come under the Colorado River Basin Salinity Control Program. Because the Bureau of Reclamation has been actively involved in the Big Sandy River Unit study for 3 years, this agency would likely assume the responsibility and cost for the feasibility study.

WHO ACTS

The Bureau of Reclamation could initiate action under the existing Big Sandy River Unit study.

ENVIRONMENTAL AND SOCIAL IMPACTS

There are no environmental or social impacts associated with the feasibility study. Impacts should be considered in the feasibility study for the control alternatives developed. An important environmental impact might be lower base flows in the river. A social impact might be increased Federal or State involvement in the area.

OPTION 6
NO ACTION

PROBLEM STATEMENT

Taking no action is construed in this case to mean no further action beyond what is being done at the present. This option, then, would be limited to a continuation of the programs of BLM, DEQ, and the State Engineer to control discharge of saline water from wells and a continuation of the Big Sandy Unit study.

Salinity levels in the study area are presently causing economic and health impacts on domestic and industrial water users. The costs associated with industrial and domestic water use in the Green River Basin have been discussed in Chapter 4.

As noted on Table 8-2, all the use impairments are attributed at least in part to natural ground water discharges. Those impairments in Bitter Creek, Killpecker Creek, and Hams Fork are caused entirely by natural ground water discharges. Efforts to remove these three streams from their natural state in order to remedy salinity problems would be technically difficult, economically expensive, and perhaps environmentally unsound.

Salinity problems in the other reaches have controllable sources and have caused discomfort to the stomach and the pocketbook; but they have not appeared to discourage the use of the water. High salinity in the streams may be more tolerable to many in the study area than some of the salinity controls. For example, the irrigation controls presented in other options would involve more regulations, more government intervention, more costs, and less personal freedoms than ranchers presently experience (or perhaps would be willing to experience).

MANAGEMENT ACTION

The only actions involved in this option are to allow the programs mentioned above to continue and to allow individual decisions by water users concerning independent actions affecting their own economic picture. For example, if the cost to an industry, for treating the present water is higher than the cost of developing and operating a pipeline to a better water source, then it may be wiser for them to secure a better source if it is available to them under the existing water rights picture. The same analysis could be made by domestic suppliers as well.

EXPECTED CONTAMINANT REDUCTION

No reduction in salinity is expected as a result of this action. In the future, salinity concentrations may increase because of more irrigation in the Bridger Valley due to the Lyman project and more diversions and depletions of high quality water for industrial and domestic use.

EXPECTED COSTS

Existing costs related to salinity were estimated in Chapter 4. The analysis in Chapter 6 indicated that development under the energy export and coal export scenarios would have little impact on costs of water use in the study area, although some costs would be incurred by water users outside of the study area under the energy export scenario. Diversion of high quality water, such as from Fontenelle Reservoir, would have major economic impacts on water users both in the study area and downstream from it. Therefore, water resources development without consideration of water quality may be costly to present and future water users.

BENEFITS AND TO WHOM

Those who benefit by such an action would be those to whom the costs could accrue if any of the other possible actions were taken. The general situation in the study area is that those who cause salinity are upstream and those who benefit from salinity reductions are downstream. Thus, those who benefit are not necessarily those who pay for salinity control.

WHO PAYS

Costs of ongoing programs would continue to be borne by BLM and DEQ in the management of exploratory and other wells and by the Bureau of Reclamation and USDA in the Big Sandy Unit study. Costs for salinity treatment would be paid by the industrial users and the domestic suppliers and their customers in the study area as well as outside of it.

A possibility exists that this option may restrict Wyoming's rights to develop water apportioned to it under the Colorado River Compact. Salinity is a recognized national and international water quality problem in the Colorado River Basin. If Wyoming does not make reasonable efforts to control salinity loads and concentrations within its borders, the Federal government may be able to prevent water resources development in the State on the grounds that it would severely degrade water quality in the Lower Colorado River. Such a restriction would severely hamper economic growth in Wyoming.

WHO ACTS

BLM and DEQ would continue to act as described above.

Independent actions would take place on the part of individual industries or domestic suppliers in accordance with their perceived economic picture.

ENVIRONMENTAL AND SOCIAL IMPACTS

Because this option is a continuation of the existing system, it would probably have the least social impact of any of the salinity control options. The environmental impacts include continued economic-related and health-related problems due to high salinity.

OPTION 7
SALINITY STANDARDS IN THE STUDY AREA

An important distinction exists between the water quality criteria developed in Chapter 2 and water quality standards. The criteria developed in this report are numeric values used to judge existing and future water quality in terms of the water quality goals in the study area. They differ from standards in that standards are adopted by an administrative agency for the regulation and enforcement of water quality.

The criteria for specific salinity species given in Chapter 2 concern the protection of water for industry, agriculture, wildlife and livestock watering, public water supply, and fisheries. The feasibility of adopting these criteria as standards is examined under this option. In addition, this option will describe investigations about an economic-based salinity criterion that can be applied in the area. A recommendation for adoption will be made if the standards protect water quality for beneficial use; if they are attainable at reasonable economic, environmental, and social cost; and if they are legally defensible.

PRECEDENT FOR SALINITY STANDARDS IN THE STUDY AREA

EPA promulgated in the *Federal Register* on December 18, 1974, a regulation establishing a Colorado River System Salinity Control Policy and Standards Procedure (40 CFR, Part 120, Water Quality Standards). The pertinent parts of this regulation are presented below:

> (b) It shall be the policy that the flow weighted average annual salinity in the lower main stem of the Colorado River System be maintained at or below the average value found during 1972. To carry out this policy, water quality standards for salinity and a plan of implementation for salinity control shall be developed and implemented in accordance with the principles of paragraph (c) below.
>
> (c) The States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming are required to adopt and submit for approval to the Environmental Protection Agency on or before October 18, 1975:
>
> (1) Adopted water quality standards for salinity including numeric criteria consistent with the policy stated above for appropriate points in the Colorado River System; and,
>
> (2) A plan to achieve compliance with these standards as expeditiously as practicable providing that:
>
> (i) The plan shall identify State and Federal regulatory authorities and programs necessary to achieve compliance with the plan.
>
> (ii) The salinity problem shall be treated as a basinwide problem that needs to be solved in order to maintain lower main stem salinity at or below 1972 levels while the basin States continue to develop their compact apportioned waters.

> (iii) The goal of the plan shall be to achieve compliance with the adopted standards by July 1, 1983. The date of compliance with the adopted standards shall take into account the necessity for Federal salinity control actions set forth in the plan. Abatement measures within the control of the States shall be implemented as soon as practicable.
>
> (iv) Salinity levels in the lower main stem may temporarily increase above the 1972 levels if control measures to offset the increases are included in the control plan. However, compliance with 1972 levels shall be a primary consideration.

Wyoming has complied with the requirements in this regulation through the adoption of the standards and salinity control program of the Colorado River Basin Salinity Control Forum. The adopted water quality standards for salinity are the following flow-weighted average annual concentrations of total dissolved solids:

- 723 mg/l at the station below Hoover Dam
- 747 mg/l at the station below Parker Dam
- 879 mg/l at Imperial Dam

These standards are based on the average concentrations at each station in 1972. All three stations are more than 500 miles south of the study area. There are no numeric instream salinity standards in the study area.

The salinity control program proposed by the Forum and adopted by Wyoming includes the present Big Sandy Unit study on the control of nonpoint salinity loadings from the Big Sandy River. This project is one of 17 Federal projects in the Colorado River Basin designed to control salinity. Completion of all 17 projects was originally predicted to allow full development of Colorado River compact-allocated water in the Upper Basin without increases in salinity concentrations in the Lower Basin beyond the levels set in the standards. However, this prediction is no longer considered valid by EPA and the Bureau of Reclamation.

RATIONALE FOR SALINITY STANDARDS IN THE STUDY AREA

Use impairments due to excessively high salinity concentrations are summarized on Table 8-2 at the start of this chapter. There are two types of salinity problems in the study area. First, increases in general salinity (expressed as total dissolved solids or specific conductance) have resulted in greater costs of water treatment for industry and domestic water users. Second, with regard to specific salinity species, high concentrations of sulfate have caused health problems in Rock Springs and Green River; and high concentrations of sulfate, chloride, and total dissolved solids have the potential for causing health problems for livestock and wildlife.

Salinity control, both general and species-specific, can relieve these salinity problems and create economic and health benefits in the study area. Some of the salinity control options discussed earlier in this chapter are economically feasible (benefit-cost ratios greater than one) when considering the basin as a whole; none has a favorable benefit-cost ratio within Wyoming alone. The reason for a standard, whether for general salinity or for a specific species, is to provide a basis for measuring achievement and enforcing control programs.

The salinity standards adopted by Wyoming through the Colorado River Basin Salinity Control Project apply only to levels in the Lower Basin and cannot be used to regulate directly salinity concentration or loads in the study area. A new set of standards would be necessary if a salinity control policy were adopted for the study area.

PREFERRED LOCATIONS OF SALINITY STANDARDS STATIONS

Stations for monitoring salinity would be required in the study area and would have three purposes: (1) to monitor sulfate, chloride, and total dissolved solids concentrations to ensure that they do not exceed health standards for people, livestock, or wildlife; (2) to monitor salinity loads for the Colorado River Basin Salinity Control Project; and (3) to control salinity for the economic benefit of the study area. The set of stations for the first two purposes should include at least those listed on Table 8-5.

The recommended stations for the third purpose include the following already in existence:

- Green River at Big Island
- Green River near Green River
- Green River below Green River
- Blacks Fork near Little America

These four stations are located above reaches where water treatment costs in the study area may be significantly reduced by salinity control, and below areas with the potential of greater salt delivery. The station near Green River has been included because it is still unclear how much of the salt load generated in the Big Sandy watershed reaches the Green River system through ground water discharge below the station at Big Island compared with direct discharge from the Big Sandy itself.

RECREATION AND FISHERY-RELATED INSTREAM SALINITY STANDARDS

The stated goal of the 1972 Clean Water Act and a policy of EPA is the protection of waters for recreational uses and for desired species of aquatic biota through a National Water Quality Standards Program. No salinity criteria developed in Chapter 2 were related to recreation. One criterion, that alkalinity must be 20 mg/l or more as calcium carbonate unless natural concentrations are less, concerns the protection of fisheries. No reaches in the study area have had violations of this criterion. Therefore, the criterion is achievable under existing conditions. It also appears achievable under the scenarios of future conditions presented in Chapter 6.

Table 8-5

SALINITY MONITORING STATIONS

Monitoring Stations	Storet Numbers
Green River near LaBarge	09209400
Green River below Fontenelle Reservoir	09211200
Green River at Big Island	09216300
Green River near Green River	09217000
Green River below Green River	09217010
Big Sandy Reservoir	560101
Big Sandy River below Eden	09216000
Big Sandy River at Gasson Bridge	09216050
Pacific Creek near Farson	09215000
Bitter Creek above Salt Wells Creek	09216562
Blacks Fork near Millburne	09218500
Blacks Fork near Lyman	09222000
Blacks Fork near Little America	09224700
Smiths Fork near Lyman	09221650
Muddy Creek near Hampton	09222400
Hams Fork near Granger	09224450
Henrys Fork near Manila	09226000

It is recommended under this option that DEQ not adopt this criterion as a standard. The situation in which a water user would dilute the alkalinity below 20 mg/l in any of the Southwestern Wyoming streams is extremely unlikely. Therefore, a standard appears meaningless. If the rare situation described above arises, it would appear to be preferable to allow the dilution rather than to force the user to add alkalinity to the water, thereby increasing salinity in the Colorado River system.

HEALTH-RELATED INSTREAM SALINITY STANDARDS

The criteria developed in Chapter 2 contain certain values related to the health effects of salinity. These effluent limitations include--

- Chloride less than or equal to 2,000 mg/l for wildlife and livestock watering.
- Sulfates less than or equal to 3,000 mg/l for wildlife and livestock watering.
- Sulfates less than or equal to 250 mg/l for public water supplies.
- Total dissolved solids less than or equal to 5,000 mg/l for wildlife and livestock watering.

It is recommended under this option that these criteria be considered for adoption as instream standards in the study area by DEQ. Maximum instream concentrations should not be allowed to exceed these levels in any sample. This recommendation reflects the existing national and State policy where standards are promulgated for public health-related welfare.

Those reaches with impaired uses due to instream concentrations which exceeded the four criteria listed above are--

- Green River reach (public water supply)
- Flaming Gorge Reservoir (public water supply)
- Upper Bitter Creek (wildlife and livestock watering)
- Killpecker Creek (wildlife and livestock watering)
- Lyman reach of Blacks Fork (public water supply)
- Lower Hams Fork (public water supply)

Salinity standards could be met in these reaches either by reducing or diluting salinity loads or by abandoning the impaired uses in these reaches.

The three reaches along the main stems of the Green River and Blacks Fork lie below areas in the Big Sandy and Bridger Valley with economically feasible salinity control projects. Adoption of health-related salinity standards in these reaches would encourage progress on these projects. Without salinity modeling in the area, it is unknown whether the feasible salinity control measures can reduce salinity concentrations to the level required by the standards. However, these measures can probably bring maximum instream concentrations closer to the standards and reduce the amount of time instream standards are exceeded.

The other three reaches listed above do not lie below feasible salinity control projects. Rather than to promote salinity control projects, salinity standards in these reaches can indicate to users when water use should be restricted because of possible health impacts. For example, users in the Lower Hams Fork may seek to obtain rights for storage of water and use the stored water during the periods of high sulfates in mid-winter.

ECONOMIC-RELATED INSTREAM SALINITY STANDARDS

The Colorado River System Salinity Control Standards are based on salinity control for the economic benefit of agriculture, industry, and domestic water users in the Lower Colorado River Basin. As discussed earlier, they cannot be used to control salinity explicitly for the benefit of users in the study area. Therefore, additional salinity standards may be needed to control salinity in the study area for the economic benefit of those in the study area and in Wyoming.

Among the salinity criteria developed in Chapter 2, only the SAR-TDS criterion for agriculture is economic-based. Nine reaches are indicated as impaired for agricultural use because instream concentrations exceed this criterion. However, no farmers or ranchers in any of these reaches have noted a curtailment of crop production because of poor water quality. There are two explanations for this discrepancy: first, irrigation water is usually diverted from the upper end of a reach, where water quality is significantly better than that recorded for the reach at stations downstream; second, the practice of flood irrigation washes out salts which have accumulated during the irrigation season. For these two reasons, salt concentrations have not been a problem to agriculture in the study area. To adopt the SAR-TDS criterion as a standard may focus attention away from the more severe salinity problems for domestic water users, industry, and wildlife and livestock. Therefore, it is recommended under this option that the SAR-TDS criterion not be adopted as a standard in the study area.

Industry and domestic water users in the study area would benefit from a control in salinity. When comparing these benefits with their costs, however, the ratio is not favorable. For this reason, standards are not recommended under this option to provide benefits only to users within the study area.

However, when comparing benefits basinwide, with costs of general salinity control within the area, a favorable ratio exists. It therefore seems reasonable to recommend under this option that both point and nonpoint source control programs be implemented, including some or all of the other options described in this chapter. Standards can aid in the enforcement of these programs.

The question remains, then, what standard should be applied in order to measure the need for control and the achievement of control. As described before, the Colorado River Basin Salinity Control Forum has adopted water quality standards but at points more than 500 miles downstream from Wyoming. DEQ cannot use those standards to provide the required measurement. Under this option two methods of establishing numeric standards for Wyoming have been investigated. Neither can be recommended at this time for reasons explained below. Another way is to establish salinity standards for Wyoming through judicial proceedings; that is the route chosen by the Environmental Defense Fund in its suit against EPA and other Federal agencies in August 1977. The case was still in court at the time this report was published.

The two methods for establishing scientifically based standards that were investigated in this study are described in the following material. The policy behind both is a maintenance of salinity at existing levels. Included are the reasons why they were not recommended. It is hoped that this information will be of value to those who may be asked to develop salinity standards in the future.

The precedent has been set in the Colorado River Basin to peg economic-related salinity standards in the Lower Basin to 1972 flow-weighted instream total dissolved solids concentration. Because of this precedent, the possibility of using 1972 flow-weighted conditions in the study area for economic-related salinity standards was investigated in detail. This approach was found unsuitable for two reasons.

First, while flow-weighting is a good way to describe salinity levels instream over a wide variety of conditions, it is not appropriate for the study area because industrial and domestic water users are more concerned with actual salinity concentrations in their intake water. In 1972, users of Green River water near Green River experienced an average intake salinity of 529 μmhos. The flow-weighted average instream salinity concentration for 1972 at that station was 456 μmhos. The flow-weighted average would significantly underestimate the costs of salinity to users during that year.

Second, uncontrollable natural climatic changes in precipitation cause large changes in salinity concentrations. Figure 8-2 shows salinity levels at two stations for 6 years (1970-75) and compares these levels with the average salinity level for 1960-75 for the same stations. Although salinity concentrations in 1972 were within 5 percent of the long-term average at the two stations, there is considerable variation from year to year. The primary reason for those variations is changing amounts of precipitation on the watershed. Surface runoff is low in salts compared with ground water discharge. Generally, when surface runoff is high it dilutes ground water salinity contributions; when surface runoff is low, higher instream salinity results because ground water has more influence. Because of the wide variability from year to year, selecting a single year's value for the standard means that natural rather than manmade conditions could cause violation of the standard. The situation makes a measurement of the effects of management programs impossible.

The second method investigated for establishing a scientifically based general salinity standard uses a statistical approach rather than a single year's value. Here, recognizing the natural scatter of salinity levels described above, the values over several years were plotted for the same two stations. This is shown on Figure 8-3. The approach tries to build upon the relationship that lower runoff years have higher instream salinity

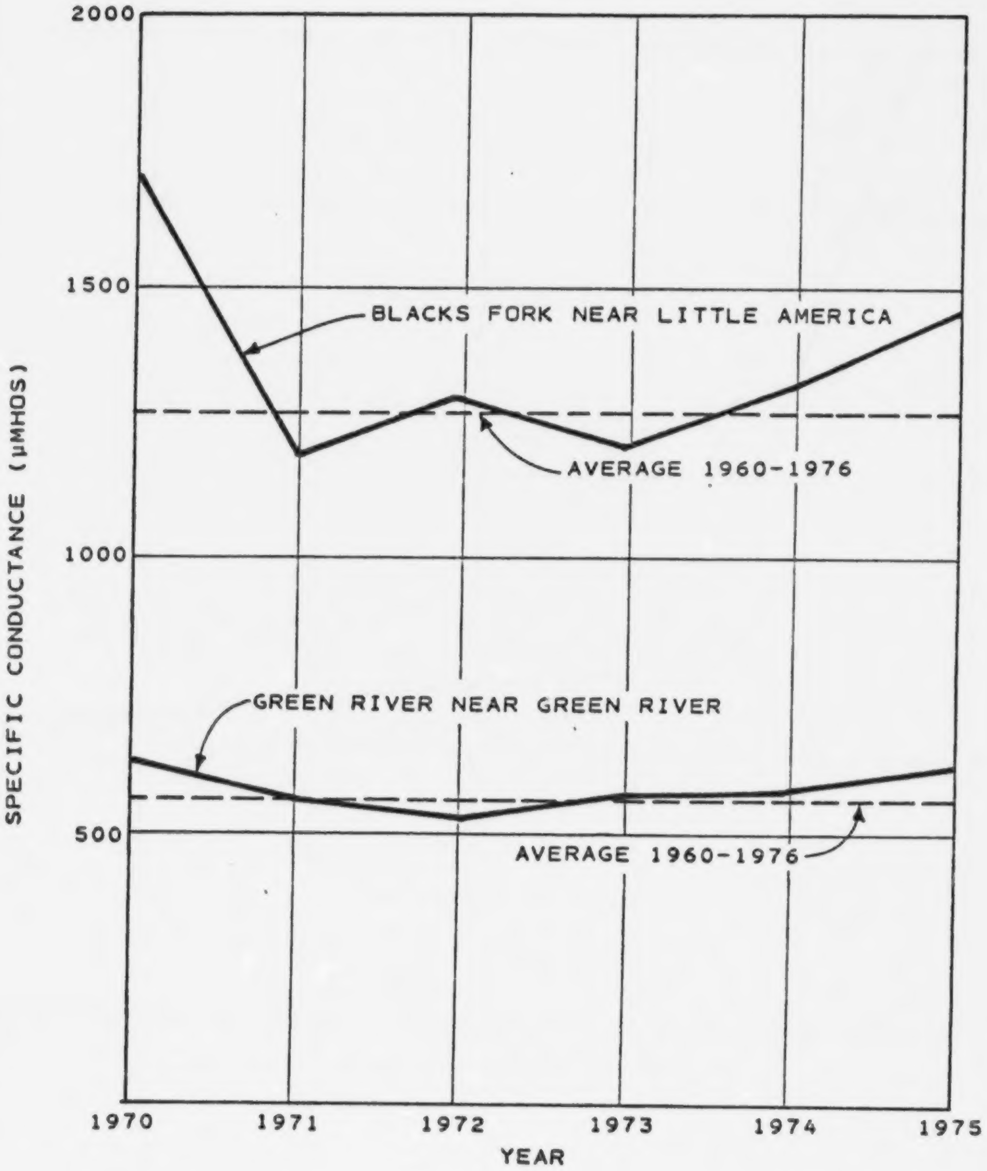

FIGURE 8-2

ANNUAL SPECIFIC CONDUCTANCE
AT TWO STATIONS

CH2M HILL

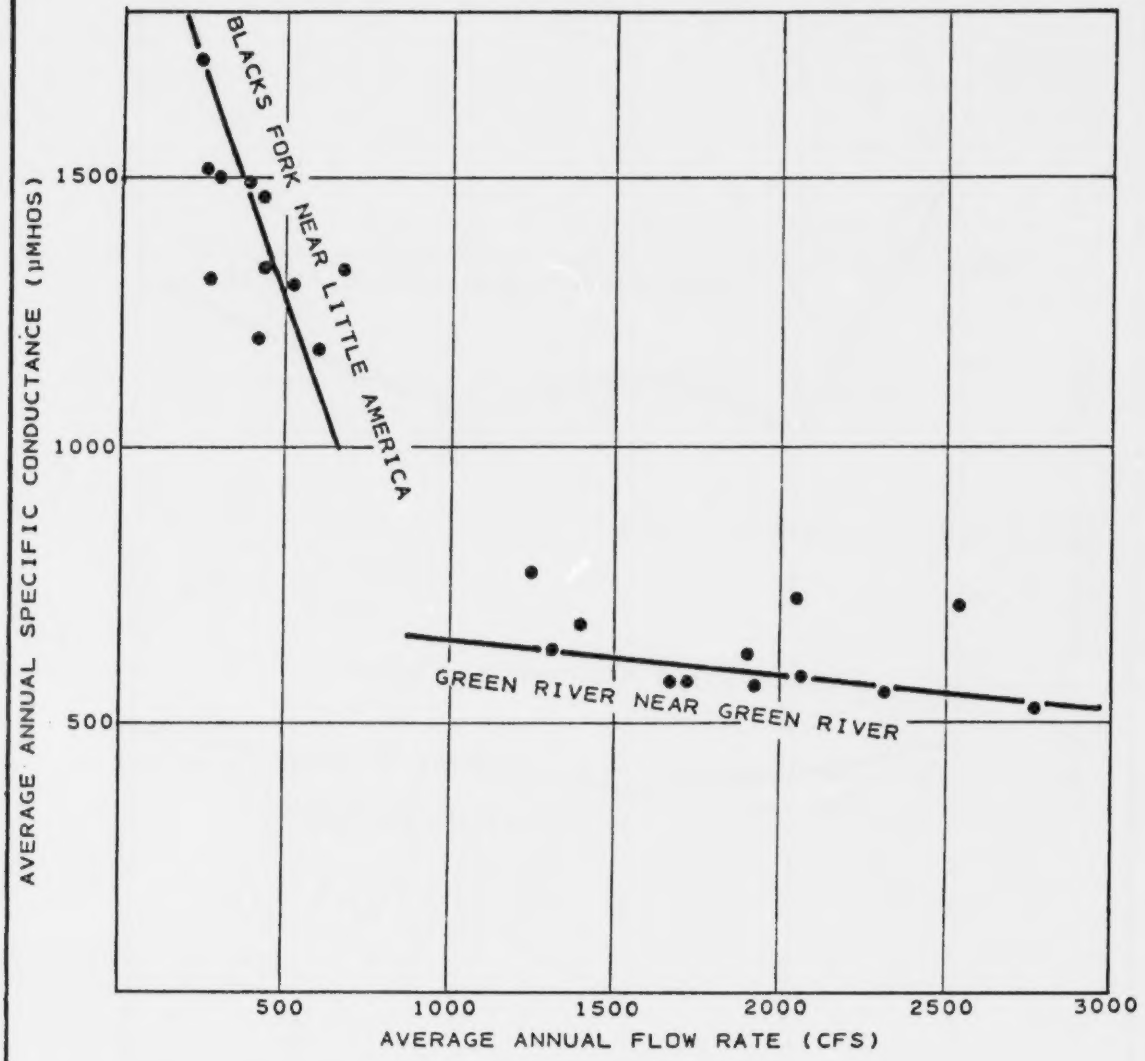

FIGURE 8-3

ANNUAL SPECIFIC CONDUCTANCE
AS A FUNCTION OF THE AVERAGE
ANNUAL FLOW RATE

and higher runoff years have lower salinity. If a sound statistical relationship can be established between salinity and flow levels, then a rule curve can be established against which to make measurements. The rule curve becomes, in effect, a standard. When salinity levels are above the rule curve, it would be assumed that man-induced conditions caused the increase and the need for more control would be as evident as if a standard were violated. Figure 8-3 shows that definite patterns emerge for the two stations, and that each station has its own characteristic. However, because natural causes deliver as much as 80 percent of the salinity at the Green River station and as much as 60 percent of that at the Blacks Fork station, as little as 20 percent change in the Green River natural conditions from one year to another would completely mask any salinity contributions made by all other sources. This means the method would not be sensitive to changes in man-induced salinity loads. Perhaps with 10 to 15 additional years of record, this approach could be used more satisfactorily.

EFFLUENT LIMITATIONS FOR POINT SOURCES

The Colorado River Basin Salinity Control Forum adopted a Policy for Implementation of the Colorado River Salinity Standards through the NPDES Permit Program on February 28, 1977. The effluent limitations contained in Forum Policy and summarized below are the basis for point source control of salinity.

The objective for industrial sources is a no-salt-return policy. Each new or existing industrial facility is judged on an individual basis. If the objective cannot be attained for a particular facility, discharges of up to 1 ton per day or 350 tons per year may be allowed. Although not specifically stated, it is assumed that industrial sources also include discharging wells drilled for exploration of water or oil and gas.

The objective for municipal sources is an incremental increase of 400 mg/l or less above the flow-weighted average salinity of the intake water supply or a maximum discharge of 1 ton per day or 350 tons per year, whichever is less. Each municipal facility is judged on an individual basis. Requirements may be waived for a particular facility if there is no reasonable way of attaining the objective.

It is recommended under this option that these standards be included in the NPDES permits for dischargers to the Green River system. Technology is available to meet the discharge standards in the study area. The technology includes evaporation ponds, distillation, reverse osmosis, and other removal techniques.

Consideration has also been given to limiting salinity concentrations in the industrial and municipal discharges to 879 mg/l, which is the flow-weighted 1972 salinity concentration in the Lower Colorado River at Imperial Dam. However, this concentration limit has no meaning in terms of use protection in the study area, and therefore it does not appear to be a defensible standard.

The Wyoming Department of Environmental Quality (DEQ) has developed rules relating to the surface discharge of water associated with the production of oil and gas (Chapter VII, Wyoming Water Quality Rules and Regulations). Section 4 of the rules contain the following effluent limitations:

- Chlorides must not exceed 2,000 mg/l in any sample
- Sulfates must not exceed 3,000 mg/l in any sample
- Total dissolved solids must not exceed 5,000 mg/l in any sample
- pH must be between 6.5 and 8.5 in all samples
- Oil and grease may not exceed 10 mg/l in any sample

The State also reserves the right to impose limitations on other parameters.

It is recommended under this option that DEQ continue to include these conditions in discharge permits for oil and gas.

WASTELOAD REDUCTIONS FOR NONPOINT SOURCES

Wasteload allocations for nonpoint sources are a difficult task. First, there is commonly no single discharge point from a nonpoint salinity source, so monitoring of salinity loadings from the source is difficult. Second, the reduction in salinity loadings from a nonpoint source due to the institution of certain management practices is difficult to predict accurately. Because of these two problems, wasteload allocations have generally not been attempted for nonpoint sources. However, the salinity budget in Chapter 5 shows that essentially all of the present salt load generated in the study area comes from nonpoint sources. This trend may be expected to continue. Therefore, salinity control in the study area dictates control of nonpoint salinity sources.

The proposed objective of economic-related instream salinity standards is no increase in salinity concentrations over existing levels. Even though specific numeric levels cannot be developed in this report, as described earlier, the salinity reduction objective is just as valid, and each project or area can be considered on an individual basis. This objective may then be attained by no net increase in salinity concentrations due to salinity loadings from nonpoint sources. An example of how this reduction scheme would work is presented below for a hypothetical project.

A hypothetical project involves the construction of a reservoir near Big Island to store surplus early-season runoff on the Green River. This project could increase salinity directly by evaporation and seepage or indirectly by provision of water for irrigation in the contact zone.

Under the wasteload allocation system proposed for nonpoint sources, the effects of the project on salinity concentrations at Green River near Green River would have to be balanced by salinity control measures above that station. Control measures could include options mentioned earlier, such as better timing of irrigations or a change from flood irrigation to sprinkler irrigation, or other best management practices. The impact of salt changes on concentrations near Green River could be estimated through stochastic river models developed by the Bureau of Reclamation, Utah Water Research

Lab, or others. Approval of the hypothetical project would be contingent on finding and instituting best management practices to balance out its salinity impacts at the station designated Green River near Green River.

EXPECTED CONTAMINANT REDUCTION

The goal of the economic-based standards considered under this option is to maintain existing salinity levels in the study area. To attain this goal may require reduction in salt loadings or increases in dilution water. The salinity control measures should also be aimed at reducing concentrations of specific salinity species below the health-based standards.

EXPECTED COSTS

Costs for developing salinity standards have not been estimated. However, these costs would probably be small compared to the potential benefits gained.

BENEFITS AND TO WHOM

Those who would benefit from salinity standards would be domestic and industrial water users, wildlife and livestock in the study area, and downstream users outside the study area. Benefits would be both economic and health related.

WHO PAYS

DEQ would incur costs in the development and enforcement of salinity standards. These costs are difficult to assess.

EPA, through the Colorado River Basin Salinity Control Forum, would also be involved in setting standards, using the same funding as now.

WHO ACTS

DEQ is the primary agency responsible for water quality managment in the State of Wyoming, and would seem to be the logical choice for administering the nonpoint program described earlier. The nonpoint program is consistent with the Wyoming standards which call for no increase in salinity levels; these standards are enforced by DEQ. Under the program, DEQ would be responsible for determining or evaluating the salinity increases associated with a specific project and enforcing the implementation of counteractive measures designed to maintain salinity loadings from nonpoint sources at their present level.

While the institutional framework described above would probably be the most centralized and effective, DEQ may not have the authority to enforce counteractive measures. An alternative is that the State Engineer could implement the program if a project involved a new water right or a transfer of water rights. Most new, large projects in the study area will probably require either a new water right or a transfer, and therefore would come under the authority of the State Engineer.

Another alternative for the nonpoint program is to implement the program through the process of environmental impact statements. A statement would investigate the salinity impacts of a particular project and give detailed consideration to measures which would counteract the salinity increases. The management or permitting agency would then weigh the water quality impacts with economic, social, and other environmental impacts of the project in order to come to the decision whether salinity levels should be maintained. This approach would probably be less consistent than the other two and may not be as successful in maintaining salinity levels; however, it probably would offer the most balanced consideration of all factors which determine if a project is justifiable.

DEQ would eventually institute instream salinity standards for the study area when possible. Authorization for this action comes under the Wyoming Environmental Quality Act, 1973 Session Laws, Chapter 250, Section 1. DEQ would review all water and oil and gas resource development projects in the study area and determine what measures need to be taken in order to meet the instream salinity standards.

Discharge permits for point sources would be issued by DEQ under the NPDES permit program. Surveillance of those discharges for compliance would also be the responsibility of DEQ.

It is important to realize that salinity standards may not be an option for Wyoming if the Court decides that Stateline standards must be promulgated as a result of the suit brought by the Environmental Defense Fund. The case was in court at the time this report was published.

OPTION 8
CONTROL OF WATER RESOURCES DEVELOPMENT AND DRILLING ACTIVITES IN AREAS WHERE SALTS CAN BE MOBILIZED

PROBLEM STATEMENT

Two proposed water resources projects, the Plains Reservoir and the Stateline Project, provide good examples of the reasons for this option. The locations of the two projects are shown on Figure 8-4, which is a reproduction of Figure 5-17. As seen on Figure 8-4, the Plains Reservoir would be located in a critical geologic area along the contact zone between the Bridger and Wilkins Peak Formations. Percolation from the reservoir would enter this contact zone and very likely cause heavy leaching of salts. The significance of this contact zone is described in Chapter 5. The Meeks Cabin Reservoir is not on the contact zone itself; however, the areas that will be irrigated as a result of that project are on the contact zone, and irrigating those areas will increase salinity in surface and ground water bodies without the institution of salinity control measures, as shown in a report prepared for the State Engineer's Office (Skogerboe, 1973).

Four possible conditions may be created which will increase the movement of ground water through the critical areas shown on Figure 8-4 and increase salt loadings to surface water from ground water. These four possible mechanisms are described below.

Irrigation or reservoir construction over saline soils and bedrock may increase salt loadings to surface waters. A good example of where such a mechanism is happening is in the Bridger Valley where soils are underlain by a shale formation. SCS personnel claim that the present irrigation practice of flooding in the Bridger Valley results in over-application of irrigation water. This excess water percolates through the soil to the shale formation and leaches the salts back up into the soil itself. During irrigation season, these salts largely stay in the soil mantle, but irrigation practice in the spring time is to use the excess spring runoff to flush the salts from the soils so that they do not build up in the plants' root zone. This flushing action liberates the salts and allows them to reach the surface streams.

The second possible condition occurs when wells or drill holes penetrate upper soil and rock layers and reach underlying layers that have high salt content and contain water under pressure. If not properly sealed, such wells can flow high saline water to the surface where it can enter surface streams or enter the ground water body. Examples of this mechanism have been found in northern Sweetwater County where exploration and other wells drilled in past years have been left to flow free to the surface. Salinity of the water in these flowing wells has reached 10,000 parts per million. As discussed in Chapter 5, two areas lack only the proper geologic structure to convey highly saline water to the surface. These areas are the Hams Fork between Kemmerer and Granger and the Henrys Fork between Manila and Burnt Fork. Drilling in these areas can modify the ground water flow regime and allow the Bridger Formation to interact with the Green River Formation. This interaction produces the "salt pump" phenomenon described in Chapter 5.

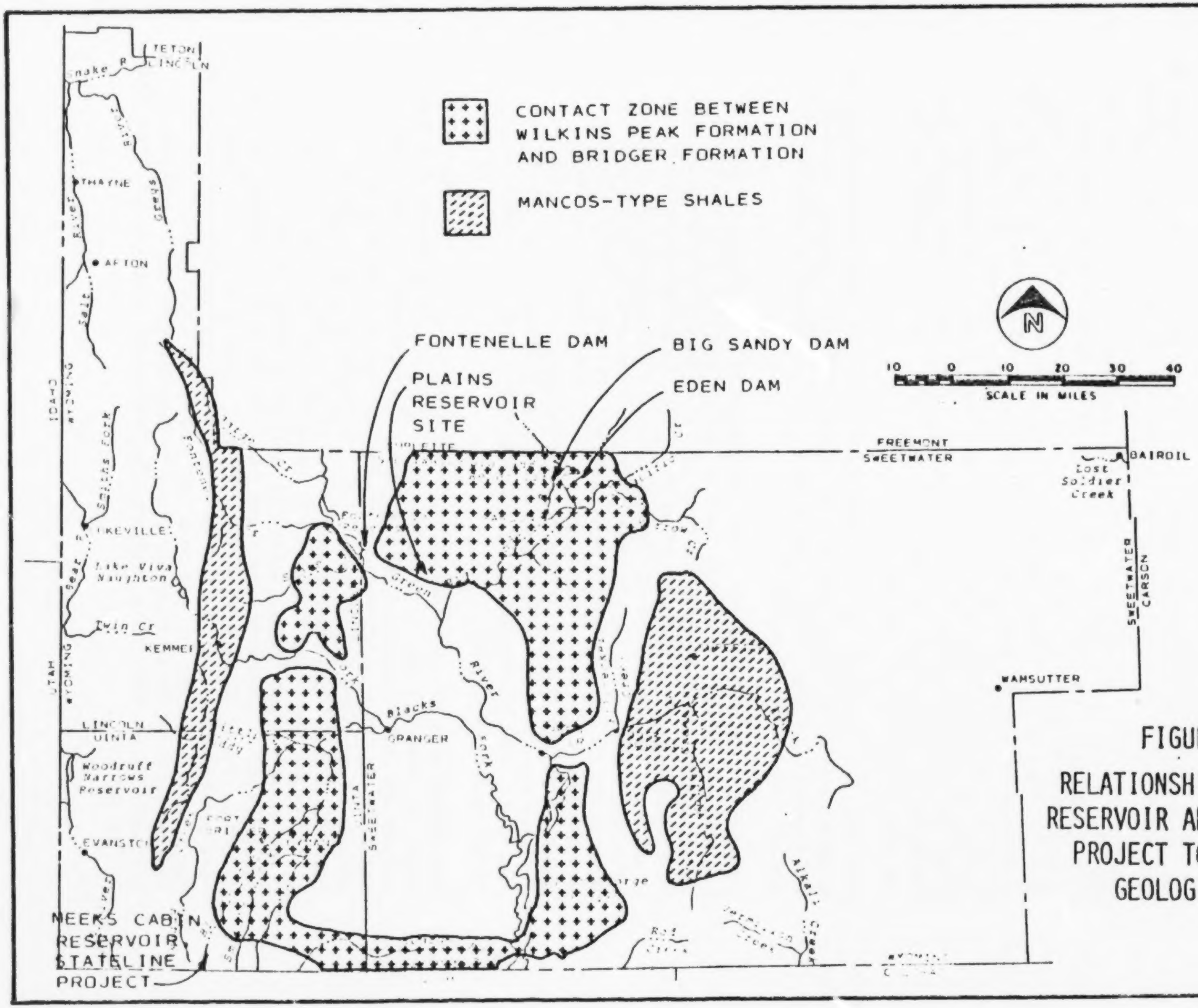
CONTACT ZONE BETWEEN WILKINS PEAK FORMATION AND BRIDGER FORMATION
MANCOS-TYPE SHALES
FONTENELLE DAM
PLAINS RESERVOIR SITE
BIG SANDY DAM
EDEN DAM
N
10 0 10 20 30 40
SCALE IN MILES
TETON
LINCOLN
Snake R
THAYNE
AFTON
Greys River
Salt River
IDAHO
WYOMING
Smiths Fork
KEVILLE
Bear R
Lake Viva Naughton
Twin Cr
KEMMER
UTAH
WYOMING
LINCOLN
UINTA
Woodruff Narrows Reservoir
EVANSTON
MEEKS CABIN RESERVOIR
STATELINE PROJECT
Green
River
Blacks
Fork
GRANGER
UINTA
SWEETWATER
FREEMONT
SWEETWATER
BAIROIL
Lost Soldier Creek
SWEETWATER
CARSON
WAMSUTTER
Alkali Creek
Red Creek

FIGURE 8-4

RELATIONSHIP OF PLAINS RESERVOIR AND STATELINE PROJECT TO CRITICAL GEOLOGIC AREAS

CH2M HILL

Of particular concern are the shallow drilling and blasting practices used in geophysical seismic oil exploration. The reason for the concern is illustrated on Figure 8-5 for the situtation in the Hams Fork and Henrys Fork. The present salinity in the two streams is predominantly calcium sulfate, leached out of the Bridger Formation. Salinity levels in the two streams are low compared to those in Blacks Fork or Big Sandy River because the interaction of the highly saline Green River Formation with surface waters is prevented by an impermeable layer of Laney shale. As shown on the figure, blasting can fracture the impermeable layer and allow water in the Green River Formation to react with water in the Bridger Formation. This interaction produces a "salt pump" of sodium sulfate to the surface waters, as described in Chapter 5.

The third possible condition under which salts can be mobilized from soils occurs where previous erosion or construction has exposed and cut through saline layers and then those layers become flooded through the development of a dam and reservoir. The contact of water with these saline layers, primarily shale, allows the salts to be leached from the ground and into the water. No examples of this condition are known to exist now in the study area.

A fourth possible condition would be if saline-bearing layers are uncovered through surface mining or construction activities and then allowed to come into contact with water whether natural or man-applied. Salts may be leached from the saline formation in these cases and, if not controlled, could reach surface water bodies and increase the salinity load there. This condition also has not been found in the study area.

MANAGEMENT ACTION

The primary management action to guard against salts being mobilized from soils is to require thorough investigation of where such potential conditions exist prior to any development occurring and requiring that existing agriculture or well drilling activities that may mobilize soils be modified or operated in such a way so as to prevent a contamination problem. BLM and DEQ each currently have a program that requires oil-and-gas wells be sealed to prevent the intrusion of highly saline ground water into other ground water or surface water bodies. The DEQ program is limited to exploration holes. State regulation of production wells falls under the jurisdiction of the Oil and Gas Commission. The State Engineer's Office issues permits for the development of ground water. Certain conditions contained in the permits are aimed at minimizing water quality impacts. These programs have been effective over the last few years and are encouraged to continue into the future.

For the situation in the Bridger Valley, see further discussion under Option 3.

The agencies most likely to undertake water resources development that might mobilize salts under one of the four conditions mentioned above are the Bureau of Reclamation and the State of Wyoming. These agencies should be aware of the location of potential problems, as shown on Figure 8-4.

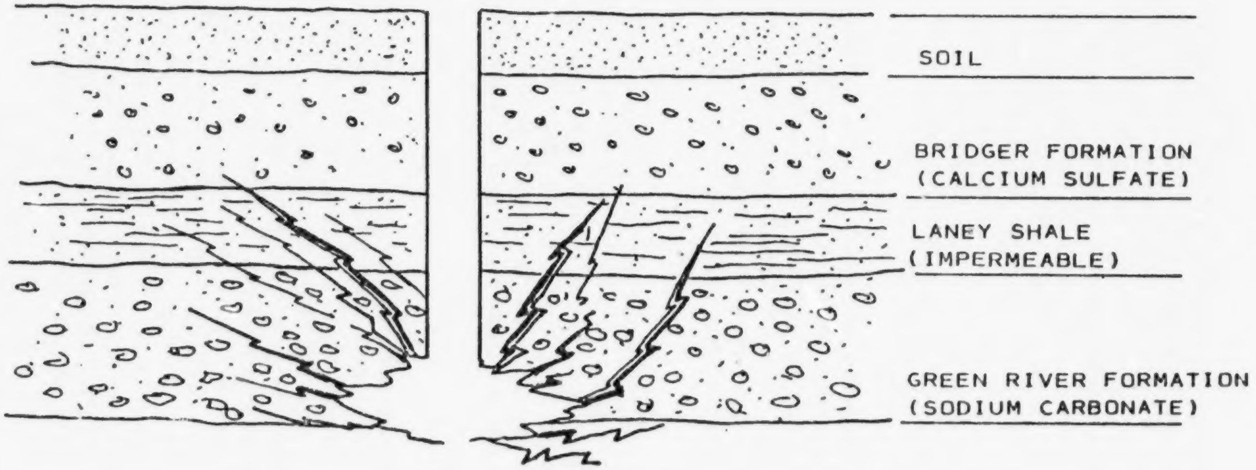
SOIL
BRIDGER FORMATION
(CALCIUM SULFATE)
LANEY SHALE
(IMPERMEABLE)
GREEN RIVER FORMATION
(SODIUM CARBONATE)

FIGURE 8-5

HOW DRILLING CAN START
THE "SALT PUMP"

They are encouraged to require study of potential water quality conditions associated with any water resources development that they may sponsor or be responsible for reviewing.

EXPECTED CONTAMINANT REDUCTION

Salinity reductions due to changes in irrigation practice in the Bridger Valley are covered under the discussion for Option 3.

Actions directed toward future water resources development can be expected to produce no net increase in salinity over current levels if proper study is done and precautions taken.

The program of BLM and DEQ wich requires the sealing of oil-and-gas wells is expected to continue to be effective and to cause no net increase in surface water salinity in the future. Furthermore, the program of BLM and DEQ to find and seal wells that may already be causing problems is likely to produce a net decrease in salinity in the study area. Specific amounts cannot be estimated due to the unknown number of such wells and due to the uncertainty of a program for capping and sealing them. In addition, existing ground water bodies may already have been contaminated with flows from these wells, and the residual effects could continue for some time even after the wells are sealed.

EXPECTED COST

Costs associated with irrigation practices in the Bridger Valley are covered under Option 3.

The costs associated with doing further study prior to water resources development will depend on where the development is proposed. Also, the investigations would probably be carried out as part of other exploratory work and the cost would not stand out as a separate item. There is a likelihood that the results of the studies may preclude some water resource development or other development in certain areas. It is also possible that actions to prevent problems, should development occur, can increase the cost of a water resources development project.

BENEFITS AND TO WHOM

Those benefiting from these salinity control actions would be those domestic, industrial, or agricultural users of water within the study area downstream from a proposed project which would cause salinity increases, as well as downstream users in the Colorado River system and outside the study area.

WHO PAYS

Costs associated with irrigation practices in the Bridger Valley are described under the discussion of Option 3.

Costs associated with proper management of exploratory and other wells would be borne by the one who is paying for the drilling. In addition, costs to manage such a program will continue to be borne by BLM, DEQ, and the State Engineer's Office.

Costs to evaluate proposed water resource projects in order to study the potential for salinity would be borne by the public, either nationally in the case of federally funded projects or statewide for State-initiated projects. If water resource development projects were undertaken by private industries, then the cost for additional study as well as control measures would be borne by them.

WHO ACTS

Discussion for Bridger Valley irrigation is contained under Option 3.

BLM and DEQ would continue to act as the management agencies related to oil-and-gas wells in the area. The State Engineer would continue to issue permits for ground water development and give detailed consideration to the ground water impacts of each case.

The Bureau of Reclamation and the State of Wyoming Water Planning Program could be charged with carrying out the necessary study for any public or private projects as appropriate that might affect salinity levels.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental impact of any of the actions under this option would be to produce no net increase in future salinity levels in surface and ground water bodies. The salinity levels present in the study area are already high enough to have significant economic and health impacts. Future increases in salinity will make these impacts more severe.

Social impacts of these actions include the possibility that some future potential water development projects may be dropped because costs associated with salinity control are too high. These consequences could result in a change in the type or extent of industrial development within the basin or where basin waters may be diverted.

OPTION 9
CONSIDERATION OF DIVERSION AND DEPLETION IMPACTS

PROBLEM STATEMENT

The impacts of different diversion and depletion scenarios were assessed in Chapter 6. It was determined in that chapter that the locations of future diversions and depletions could greatly affect salinity in the Green River and the Lower Colorado River. For example, a diversion of 92,000 acre-feet per year from Fontenelle Reservoir would cost water users in the Green River and Colorado River Basins millions of dollars per year for salinity treatment. By contrast, diversion of Big Sandy River means millions of dollars in savings for those users. Downstream impacts such as these should be considered in any fair evaluation of a proposed diversion or depletion.

MANAGEMENT ACTION

The action prescribed under this option is a review of a proposed diversion or depletion in terms of salinity impacts. The review could be conducted in the manner described below:

- The State Engineer would make predictions of future salinity levels based on the proposed diversion or depletion. He may use the "Green River Model" described in Chapter 6, which is available at the University of Wyoming, Laramie; or he may use another model or method which he determines in his professional judgment to produce satisfactory results

- If predicted total dissolved solids concentrations are less than 10 percent different from existing concentrations predicted in the "Clean Water Report for Southwestern Wyoming," Chapter 6, the State Engineer would notify the Lincoln-Uinta Association of Governments (LUAOG) and the Sweetwater County government of the change in the depletion and diversion projections.

- If predicted total dissolved solids concentrations are more than 10 percent different from concentrations predicted as above, the State Engineer would notify LUAOG and Sweetwater County before the permit is granted so that LUAOG and Sweetwater County may notify concerned individuals and agencies and take any action desired by those individuals and agencies.

The intent of this option is not to prevent future water resources development in the Green River Basin, but rather to select the most environmentally sound projects and to distribute the economic or health-related impacts on downstream water users to those gaining the benefits from water resources development.

EXPECTED CONTAMINANT REDUCTION

Reductions in salinity would depend on the specific proposed project and the mitigating measures taken.

EXPECTED COST

The State Engineer would incur additional costs in the review process. The water developer may also experience greater costs if the proposed diversion is considered environmentally unacceptable. The costs for the State Engineer and water developers would have to be estimated on a project-by-project basis.

BENEFITS AND TO WHOM

Consideration of possible water quality impacts due to water resources development may prevent worse economic and health-related salinity impacts in the study area and downstream from it. Even if a water resources project is eventually developed that leads to higher salinity levels, the review process will have alerted impacted water users and offered them a process for voicing their concerns.

WHO PAYS

The purpose of this option is to equitably distribute the cost impacts of water resources development. Secondary costs, like those experienced by downstream water users for salinity treatment, are often not considered in the total cost of a project. The review process would identify these costs and attempt to find some way of distributing them among the water developers and other affected parties. Of course, if benefits to downstream water users are realized through the development of poorer quality water, an attempt would be made to return a portion of the benefits to the water developer. This process would provide an incentive for the development and beneficial use of poorer quality water.

Agencies and units of government would incur costs during the review process itself. The State Engineer's Office, as the responsible agency, would probably experience the greatest costs. However, costs incurred by LUAOG, Sweetwater County, and others may also be substantial for individual projects.

WHO ACTS

The Wyoming State Engineer would be responsible for ensuring the proper evaluation of future water quality conditions associated with any proposed water development projects in the State. The Wyoming Department of Environmental Quality and the Wyoming Water Planning Program Office would be called in by the State Engineer to evaluate water quality factors when the project is presented to them.

If one of the evaluation criteria for a water resources development project is the benefit-cost ratio, it must be assured that all benefits and costs are included in the calculation of the ratio. The transfer of water quality and water quantity information needed to make a complete evaluation of the benefits and costs of a water resources development project can be accomplished through the IDWC.

Federal facilities are now required to meet State water quality standards, according to Section 313 of PL 92-500 and Executive Order 11752 from the EPA. Both DEQ and EPA could examine the water quality impacts of a new Federal project to see if the requirements of the executive order can be met.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental implications of a proper evaluation of future salinity impacts would be to mitigate future salinity-related impacts of water resources development. In order to allow water resources development to take place in Wyoming, some increases in salinity might be permitted after a detailed investigation of alternatives and mitigating measures.

Conditions defined during the review process for a certain water resources development project may make that project economically infeasible for the developer. The loss of the project may have social and economic impacts on the developer and others associated with the project. However, it is not planned that the review process will prevent the ultimate development of Wyoming's Compact-apportioned water.

Chapter 9
CONTROLS FOR EUTROPHICATION

Phosphorus has been identified in this study as the major cause of eutrophication in the study area's reservoirs. This chapter describes the reductions needed in phosphorus loads and the control measures available. A recommended plan to manage eutrophication will be developed and described in Chapter 11 from the information given here.

PHOSPHORUS LOADING GOALS FOR FLAMING GORGE RESERVOIR

Figure 2-5 showed the strong correlation between phosphorus levels and water transparencies for the reservoirs in the study area. The two curved lines on that figure enclose 95 percent of the data points and include all reservoirs except Viva Naughton Reservoir. Because some other factor besides phosphorus must be influencing transparency in Viva Naughton, this reservoir is not discussed further here.

Figure 2-5 is reproduced on Figure 9-1. As shown on Figure 9-1, there is no direct relationship between phosphorus and transparency levels below phosphorus levels of 30 mg/l, and therefore reducing phosphorus below that level may not mean an improvement in transparency. The phosphorus levels below 0.030 mg/l were recorded in lower Flaming Gorge Reservoir, Palisades Reservoir, and Bear Lake. Above phosphorus levels of 0.080 mg/l in the surface waters, reducing phosphorus concentrations also does not seem to improve transparency. Recognizable benefits can therefore be attained when phosphorus levels are reduced in the range between 0.080 and 0.030 mg/l.

Water quality goals related to trophic status are typically set in the mesotrophic zone. This avoids the overabundance of aquatic vegetation and algae growths associated with the eutrophic state, as well as the underproductive conditions of the oligotrophic state. The mesotrophic zone provides sufficient diversity of flora and fauna species so that adequate food chains are present to support game fish. To achieve mesotrophic conditions in the main body of Flaming Gorge Reservoir, the phosphorus levels in the reservoir's arms should be maintained at 0.030 to 0.080 mg/l.

Methodology

Two methods were used to define the phosphorus loadings which can produce mesotrophic conditions, and therefore the desirable reductions from existing loadings. Those two methods are described below.

Method 1: Vollenweider Loading Basis. Vollenweider has developed a method for estimating desirable and critical phosphorus loadings to a lake or

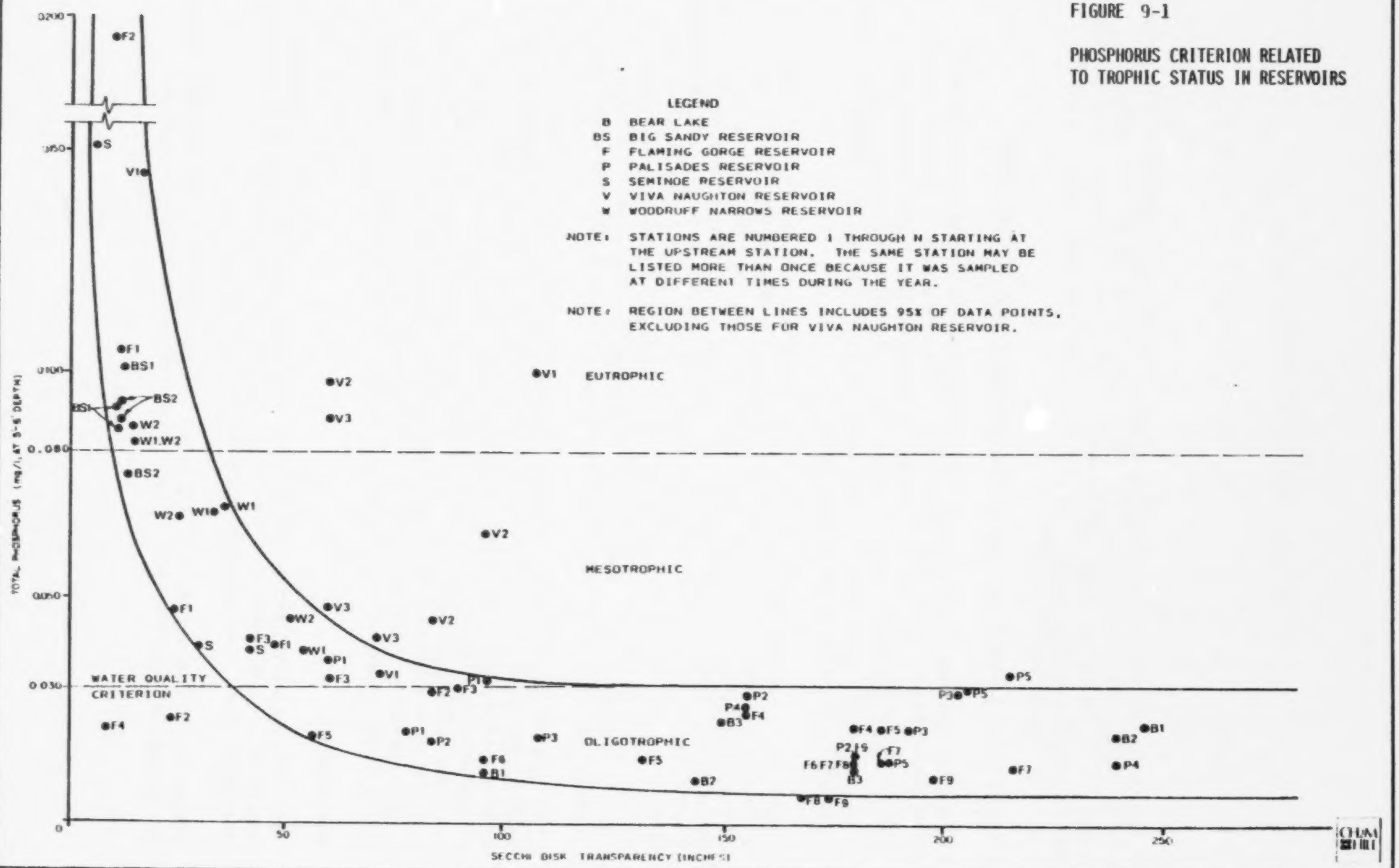

FIGURE 9-1

PHOSPHORUS CRITERION RELATED
TO TROPHIC STATUS IN RESERVOIRS

reservoir. This method is based on information contained in literature on phosphorus loadings, lake morphometry, and trophic conditions for many lakes. The Vollenweider loading chart is shown on Figure 9-2. Mesotrophic conditions are approximately represented by the area between the permissible level and the desirable level.

Vollenweider loadings are shown for various reservoirs on Figure 9-2. The data used for the plots come from EPA's draft report on eutrophication in each reservoir. They represent estimated loading rates to each reservoir in 1975. As shown in Chapter 5, phosphorus loadings during a particular year may deviate considerably from the average, because annual phosphorus loadings depend primarily on annual erosion rates, which vary significantly according to the amount and intensity of rainfall in a particular year. Therefore, the empirical estimate of the phosphorus loading rate to Flaming Gorge Reservoir from Green River and Blacks Fork is also shown on Figure 9-2. The empirical estimate is approximately three times greater than the 1975 loading rate.

The desirable loading rate reduction is shown on Figure 9-2 for Flaming Gorge Reservoir. The reduction is based on EPA estimates of 1975 loadings to the reservoir.

Method 2: Concentration Basis. Modeling of the Green River and Flaming Gorge Reservoir has shown that at the present time the severity of an algal bloom in a particular year is correlated with the phosphorus loadings to the reservoir in that year (CH2M HILL, 1975). The phosphorus stored in the reservoir from previous years does not seem to promote algal growth in the reservoir at the present time. This condition may change in the future, however, if the reservoir becomes more eutrophic.

The second method for determining permissible and desirable phosphorus loadings is based on the conclusion stated above that the severity of an algal bloom in a particular year may be correlated with the phosphorus loading to the reservoir in that year. The loadings under this method have been calculated by the following proportion:

$$\frac{\text{1975 P loading}}{\text{1975 maximum P concentration}} = \frac{\text{Desirable or permissible P loading}}{\text{0.030 mg/l or 0.080 mg/l}}$$

Desirable and Permissible Phosphorus Loadings

Desirable and permissible phosphorus loadings determined by each of the two methods are shown for Flaming Gorge Reservoir on Table 9-1. The Vollenweider method has been used just for the main body of the reservoir, while the concentration method has been used for the main body and the two arms. A comparison of the two methods indicates that the concentration method gives higher estimates for desirable and permissible loadings than does the Vollenweider method.

The table shows that the desirable loading rate is exceeded in both arms and the main body. In order to achieve desirable conditions, existing

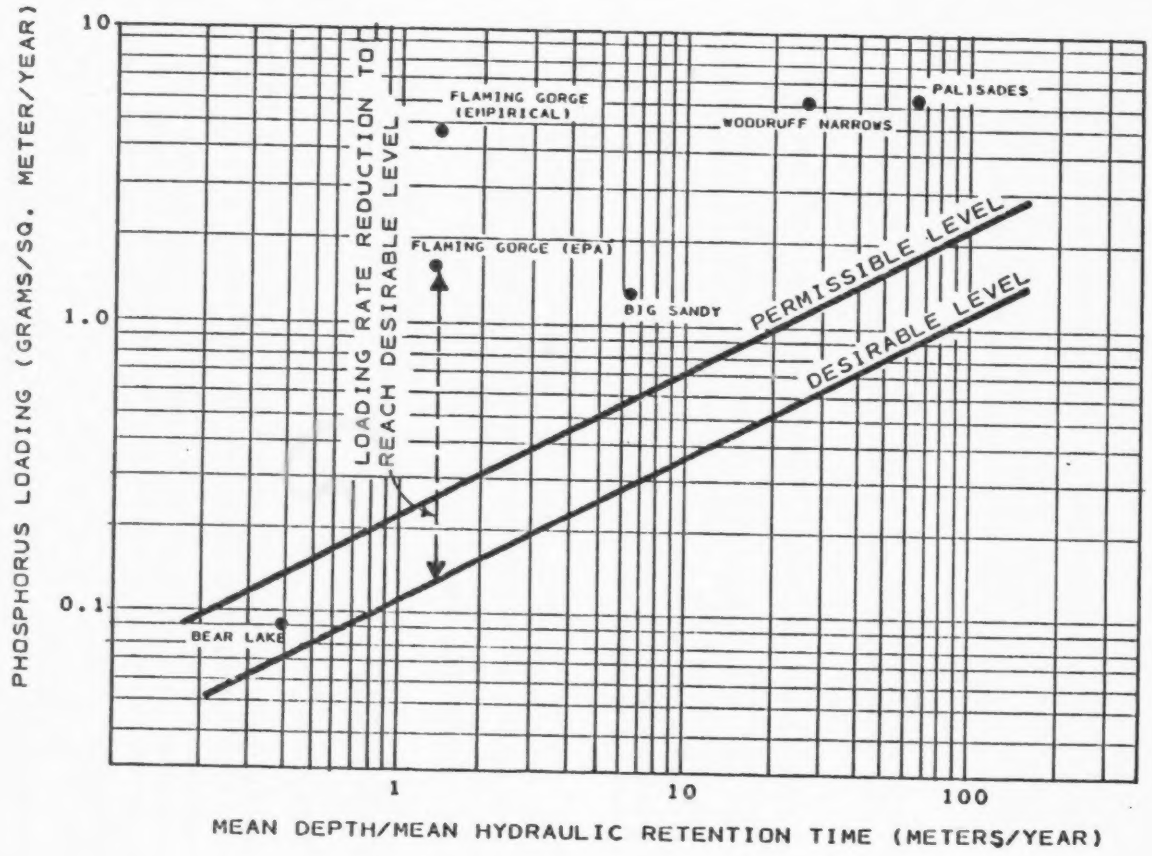

FIGURE 9-2

VOLLENWEIDER
LOADING CHART

CH2M HILL

Table 9-1

DESIRABLE AND PERMISSIBLE PHOSPHORUS LOADINGS TO FLAMING GORGE RESERVOIR
(tons/year)

Body of Water	Empirical Loading	Desirable Loading	Reduction to Reach Desirable Level	Permissible Loading	Reduction to Reach Permissible Level
Main Body, Flaming Gorge Reservoir (Vollenweider Method)	195(1)	60	135 (70%)	115	80 (40%)
Main Body, Flaming Gorge Reservoir (Concentration Method)	195(1)	95	100 (50%)	252	0 (0%)
Green River Arm (Concentration Method)	326(2)	33	293 (90%)	87	239 (75%)
Blacks Fork Arm (Concentration Method)	249(2)	13	236 (95%)	34	215 (85%)

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(1) From Table 5-14.
(2) From Table 5-12.

loadings to the main body would have to be reduced by 50 to 70 percent, to the Green River Arm by 90 percent, and to the Blacks Fork Arm by 95 percent.

The table also shows that the permissible loading rate is exceeded in both arms. In order to achieve permissible conditions, existing loadings to the Green River Arm would have to be reduced by 75 percent and to the Blacks Fork Arm by 85 percent.

Finally, the table shows that the main body of the reservoir is in a permissible condition according to the concentration method. A word of caution is necessary here, however. The phosphorus concentrations in the two arms average approximately 0.060 mg/l. As conditions become progressively more eutrophic in the two arms, phosphorus concentrations will rise because of a release of phosphorus stored from previous years in the bottom muds. Higher phosphorus concentrations in the arms will produce higher loadings from the arms to the main body of the reservoir. Therefore, maintenance of existing phosphorus loadings to the reservoir arms probably cannot maintain the existing permissible conditions in the main body of the reservoir.

CONTROL MEASURES FOR PHOSPHORUS AND EUTROPHICATION

Various optional ways to control either phosphorus levels or eutrophication are available. The goal is to reduce the algae in the reservoirs. Controlling phosphorus reduces the cause, while working on the algae treats the symptoms of eutrophication.

Twelve options for management of phosphorus are discussed in the material that follows. In each case, there is a discussion of what the control is specifically directed to, its costs and benefits, how effective it might be, who should carry it out, and what its environmental and social impacts are. An outline format similar to Chapter 8 is used consistently. The 12 controls that are discussed are listed on Table 9-2. There is no specific reason for the order given.

Each option has been developed to address the phosphorus problems listed on Table 3-8 and one or more of the principal phosphorus sources listed on Table 5-13. The relationship between phosphorus sources and management options is shown on Table 9-3.

Five of the options listed on Table 9-2 are directed at the control of geologic or accelerated erosion. These options have a secondary benefit in that they can reduce suspended solids concentrations in the streams as well as phosphorus loadings to the reservoir.

Table 9-2

WAYS TO MANAGE EUTROPHICATION CAUSES AND EFFECTS

1. Phosphorus reductions in point source discharges.
2. Institution of range management actions designed to reduce erosion in Lower Muddy Creek and Little Muddy Creek.
3. Construction of channel modifications in Middle and Lower Bitter Creek and tributaries to reduce erosion.
4. Construction of channel improvements and sedimentation ponds in Upper Bitter Creek, Muddy Creek, and Little Muddy Creek to reduce erosion.
5. Treatment of reservoirs with algicides, alum, or fly ash.
6. Erosion and manure control for all agricultural activities.
7. Erosion control for all construction and mining activities.
8. Consideration of future water quality impacts of proposed water resource development.
9. A study of eutrophication in Palisades Reservoir on a basin basis.
10. Conversion to nonphosphate detergents where a discharge to ground or surface water may result.
11. Phosphorus standards in Flaming Gorge Reservoir.
12. No action.

Table 9-3

PRINCIPAL PHOSPHORUS SOURCES AND MANAGEMENT OPTIONS

Source	Location	Management Option
Municipal Wastewater Discharges	Rock Springs Green River Kemmerer-Diamondville Granger Fort Bridger Lyman Mountain View	1, 5, 10, 11
Geologic Erosion	Lower Muddy Creek Reach Little Muddy Creek Reach Church Butte-Blacks Fork Reach Killpecker Creek Jack Morrow Creek	3, 4, 5, 11
Overgrazing and Manure Runoff	Lower Muddy Creek Reach Little Muddy Creek Reach Church Butte-Blacks Fork Reach Killpecker Creek Upper Bitter Creek Reach Salt Wells Creek Lower Big Sandy River Reach	2, 4, 5, 6, 11
Channelization	Bitter Creek Muddy Creek	3, 4, 5, 11

OPTION 1
REDUCE POINT SOURCE PHOSPHORUS DISCHARGES

PROBLEM STATEMENT

About 11 percent of the phosphorus reaching the two arms of Flaming Gorge Reservoir enters the streams through discharge from municipal treatment facilities. About half this phosphorus is of fecal origin and the other half is from the use of detergents containing phosphates.

At present there is no requirement for treatment for phosphorus removal in wastewater discharges in the study area.

MANAGEMENT ACTION

The requirement could be established that all wastewater treatment facilities, whether municipal or industrial, having a discharge permit must be required to reduce phosphorus to 2 mg/l in their discharges. An effluent concentration of 2 mg/l is attainable by alum or lime addition to the secondary process. This effluent limitation would apply to all discharges, regardless of their locations.

EXPECTED CONTAMINANT REDUCTION

For the Flaming Gorge Reservoir system and its tributaries, the total phosphorus loading from point sources is about 66 tons per year. A reduction to 2 mg/l in the effluent by additional processes of treatment facilities is estimated to reduce the total loading by about 53 tons per year.

EXPECTED COST

The costs of this option are the capital and annual operation and maintenance costs involved with adding chemical treatment processes at each of the treatment facilities. Unit costs are given on Figure 9-3 for initial capital costs and total annual costs, and the costs estimated for individual treatment facilities in the study area are summarized on Table 9-4.

BENEFITS AND TO WHOM

The benefits of phosphate reduction would accrue to the recreational users of the area's surface waters and to the tourist industry.

WHO PAYS

The capital cost for adding the necessary treatment facilities would be grant eligible since they are required for water quality considerations. The taxpayers at large would pay for a major portion of the cost with the local taxpayers picking up the remaining share. Annual operating expenses would be borne by the users of the sewer system.

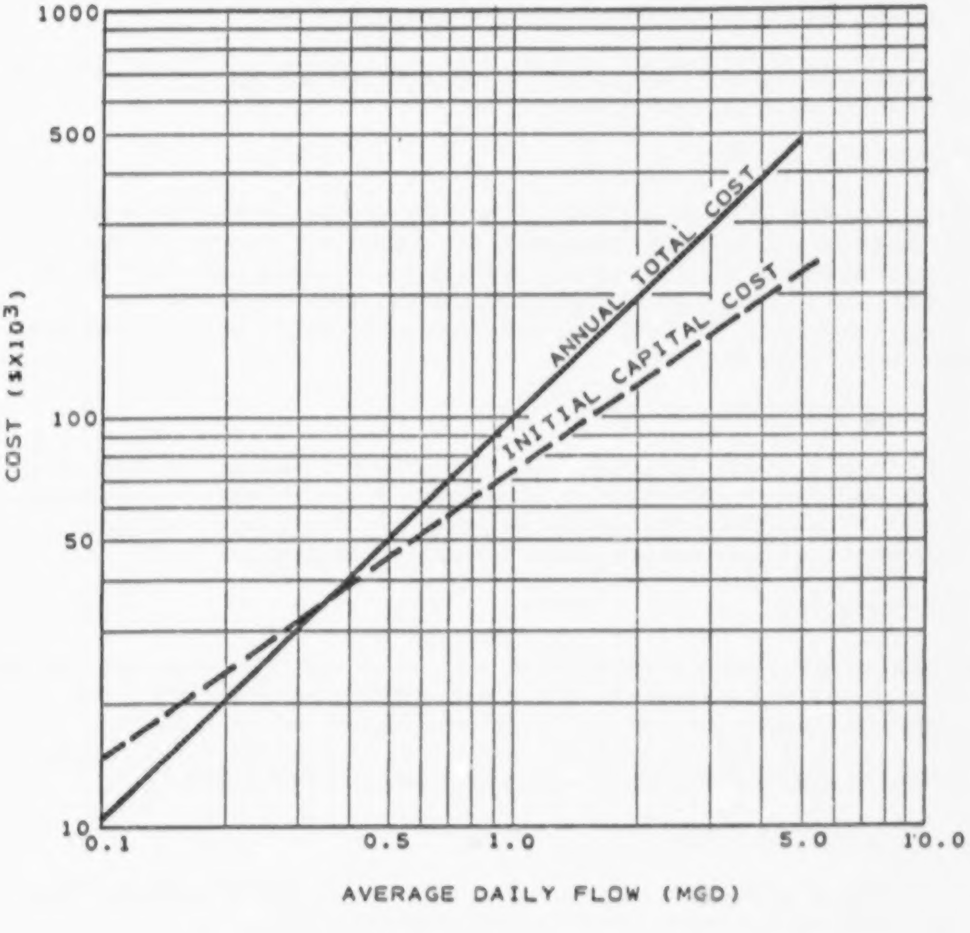

FIGURE 9-3

COST FOR PHOSPHORUS
REMOVAL FROM
POINT SOURCES

CH2M HILL

Table 9-4

COSTS OF POINT SOURCE PHOSPHORUS CONTROL

Facility[1]	Existing Average Daily Flow (mgd)	Design Flow (Year 2000) (mgd)	Initial Capital Cost	Annual Total Cost[2]
Rock Springs	1.5	3.0	$160,000	$280,000
Green River	0.7	1.2	85,000	120,000
Jamestown-Rio Vista	0.1	0.1	15,000	10,000
South Superior	0.06	0.2	17,000	12,000
Granger	0.04	0.1	15,000	10,000
Kemmerer-Diamondville	0.7	1.0	75,000	100,000
Bridger Valley	0.4	0.7	58,000	70,000
Total			$425,000	$602,000

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(1) It is assumed that smaller municipal dischargers will join into the larger districts.
(2) Sum of annual operation and maintenance costs and amortized capital costs (20 years).

WHO ACTS

The Southwestern Wyoming Water Quality Planning Association (SWWQPA) or other designated 208 planning agency would be responsible for recommending to the State that a phosphorus standard be applied to the discharges in the 208 planning area. The State Department of Environmental Quality has the responsibility for making the official action and for administering it. Monitoring of effluent levels of phosphorus would be done along with the continuous monitoring program for all treatment facilities. EPA could act in the funding capacity for construction grants, and the State would administer the construction grant program as it now does for the wastewater treatment facilities as a whole. Individual municipalities would be responsible for carrying out the planning, design, and construction of their own independent facilities.

ENVIRONMENTAL AND SOCIAL IMPACTS

The general environmental impacts associated with phosphorus reductions would apply to this action.

Adding a chemical treatment process to each treatment facility could require additional land to be occupied at the treatment site and may require additional considerations for the chemical sludges generated by the process.

Treating phosphorus in municipal discharges would result in a long-term commitment to use the chemicals involved and to carry out the process.

There are no outstanding social impacts of this action.

OPTION 2
RANGE MANAGEMENT

PROBLEM STATEMENT

Erosion was identified in Chapter 5 as the major source of phosphorus to Flaming Gorge Reservoir. Erosion control can lead to a reduction of the phosphorus loading to the reservoir. One option for erosion control is management of the range to prevent overgrazing and loss of vegetation which protects against erosion.

Four reaches tributary to Flaming Gorge Reservoir have high phosphorus loading rates and generally poor range conditions (see Table 5-9). These are Lower Muddy Creek, Little Muddy Creek, the Church Butte reach of Blacks Fork, and Killpecker Creek. A reasonable explanation for the poor range conditions in these reaches is overgrazing. These four reaches are probably the areas where grazing management can have the greatest effect on phosphorus loadings to the reservoir. Present phosphorus loadings from erosion in these reaches totals an estimated 144 tons per year, which is 38 percent of the estimated loading from all sources to the reservoir in 1976.

MANAGEMENT ACTION

The information presented in Chapter 5 suggests that overgrazing may significantly increase erosion rates and phosphorus loadings in the study area. Many assumptions had to be made to quantify phosphorus loadings attributable to grazing. These assumptions should be tested through site-specific studies and demonstration projects before widespread grazing controls are instituted, particularly in light of the significant economic and social impacts those controls may have on local ranchers.

Several alternatives or combinations of alternatives for range management should be investigated in future studies and demonstration projects in the study area. These include temporary fencing off of sections of the stream, pumping water from streams to watering holes away from the highly erosive areas, willow seeding to produce a riparian habitat, and deferred grazing.

The impact of wild animals on erosion rates should also be investigated closely. Reduction in the number of wild animals in the Green River Basin may not significantly decrease vegetative cover, because approximately 90 percent of the wild animals are browsers rather than grazers. In contrast, cattle and sheep are grazers and can have a major impact on vegetative cover in the area. However, while wild animals may have a relatively small effect on vegetative cover, they may significantly increase erosion by trampling and compacting the soil.

Management options have been analyzed on a reach-by-reach basis. In this case, where four alternatives appear possible in the four critical reaches, further studies should be initiated to pinpoint which of the alternatives, if any, is best for specific locations within a reach. These studies could take the form of environmental statements on grazing.

EXPECTED CONTAMINANT REDUCTION

Land in the four reaches with poor grazing conditions and moderate to heavy erosion rates averages approximately 40 percent vegetative cover. Most of the remainder of the Green River watershed averages 60 percent cover or better, even though the climate is arid. Decreases in erosion and phosphorus loading rates due to range management have been estimated from the Universal Soil Loss equation assuming an increase in cover from 40 percent to 60 percent. This assumption should be examined for specific areas in the environmental statements on grazing.

Erosion rates are estimated to decrease by 55 percent if cover is increased from 40 percent to 60 percent. The estimated reductions in erosion correspond to the phosphorus reductions listed below:

- Killpecker Creek, 6 tons per year
- Lower Muddy Creek, 19 tons per year
- Little Muddy Creek, 45 tons per year
- Church Butte reach of Blacks Fork, 10 tons per year

EXPECTED COST

A study should be initiated on the feasibilities of the four alternatives for the Lower Muddy Creek reach and the Little Muddy Creek reach. A proposal has been submitted by BLM for a grazing environmental statement in these reaches; an estimate of the cost of this study has not been made yet. The estimated additional costs to bring water quality considerations into the study is $25,000 to $60,000. It is difficult to anticipate the results of this study, and therefore difficult to estimate the expected costs of control measures. However, the alternatives are described below in order to indicate the amount of effort needed to control erosion and the magnitude of costs to be expected.

The length of Muddy Creek in the Lower Muddy Creek reach is approximately 30 miles, and the length of Little Muddy Creek and Albert Creek is approximately 110 miles. To fence off both reaches section by section would cost approximately $600,000. Fencing would be required in order to establish a riparian habitat of willows or other phreatophytes or in order to prevent cattle and sheep from reaching the streambed. It would also support the alternative of watering holes by forcing animals to water at the holes rather than directly from the streams. Therefore, fencing would be used under three of the four alternatives.

Pumping of water to watering holes could probably be accomplished most inexpensively by windmills. Winds are generally strong and consistent during the high flow period in spring when most of the pumping would be done. A windmill arrangement is estimated to cost approximately $12,000 if it had to pump up to 0.25 mile from the stream, or $5,000 if a well were used. Some cost elements are as follows: mill and tower, $1,650; feed line (from stream), $8,000; well (as option), $1,000 to $2,000; miscellaneous and labor, $2,350. It is estimated that up to 50 windmills could be needed along the Lower Muddy Creek and Little Muddy Creek reaches. Therefore, capital costs are estimated at $250,000 to $600,000. Annual operation and maintenance costs are estimated at 10 percent of those figures, or $25,000 to $60,000 per year.

Willow seeding is a relatively insignificant cost. However, small dams or drop structures would have to be built in order to slow stream velocities and create the proper environment for a riparian habitat. The stream gradient in either reach is not particularly steep. For example, in the Lower Muddy Creek reach, the gradient averages approximately 15 feet per mile. Costs from dams or drop structures are not estimated at this time because of a lack of adequate information.

Reduction in the number of grazing permits could have a detrimental economic impact on ranchers. The economic impact is difficult to assess accurately, however.

A cost estimate has been made for a typical project. This project would include fencing off the most critical erosion areas and pumping water to watering holes. The approximate annual cost over a 20-year period is $125,000. Further studies should be made to estimate more accurately the cost of the alternatives in the critical reaches.

BENEFITS AND TO WHOM

People who use Flaming Gorge Reservoir for recreational purposes would benefit from a reduction in algal growth. Those services related to recreational activities, such as gasoline stations and restaurants, would also benefit from good water quality in the reservoir. In addition, fisheries would benefit from a reduction in suspended solids. Finally, a decrease in erosion would extend the life of the reservoir; these benefits are probably relatively small, however, because they occur far into the future and are therefore discounted heavily.

WHO PAYS

The direct cost of this option is a grazing study in the Muddy Creek and Little Muddy Creek drainages. The costs of this study would be borne by the Bureau of Land Management (BLM). BLM has already funded an environmental statement on grazing for the Muddy Creek and Little Muddy Creek drainages. Additional funds and manpower will be needed in order to get results from this study which will be useful for future water quality management.

A possible source of additional funds is the Environmental Protection Agency (EPA), which has been authorized Federal funds through Section 304(k) of Public Law 95-12 (the 1977 Clean Water Act) to implement measures recommended in approved 208 plans. The BLM study and related demonstration projects may qualify for these funds because of the apparent importance of overgrazing to erosion and phosphorus loadings in the study area.

The selected range management alternatives and distribution of costs should be a product of the environmental statement process. Several possibilities of cost distributions which should be considered in the BLM study are presented below.

BLM and Union Pacific administer most of the land in the Killpecker Creek, Little Muddy Creek, and Lower Muddy Creek drainages. The extent of the "checkerboard" pattern within the study area is shown on Figure 9-4. In the area shaded on the figure, there are alternating sections of Union Pacific and public land. Therefore, this option would involve not only public agencies, but also Union Pacific, and costs may be incurred by both.

An alternative means of financing this option is to place the cost burdens on those who benefit from the use of the reservoir. Costs of Flaming Gorge Dam and Reservoir are allocated according to estimated benefits on Table 9-5. The users with major benefits are power generation, recreation, and irrigation. A scheme for allocating phosphorus control costs to each of these user groups is presented below.

The major beneficiary is power generation. The power plant at the reservoir is under the control of the Bureau of Reclamation. Revenues from the power plant go into the Upper Basin Fund for repayment of the dam and reservoir facilities, for operation and maintenance of the power plant, and for funding of the Colorado River Basin Salinity Control Project. Funding for the project is authorized by the Colorado River Basin Salinity Control Act (PL 93-230). Three and three-quarters percent of the total budget for the project comes from the Upper Basin Fund.

A funding process to pay for eutrophication controls could be set up parallel to that for salinity control. Control of eutrophication in Flaming Gorge Reservoir may be necessary in order to meet the interim goal of PL 92-500 of fishable/swimmable waters by 1983. Expenditures for recreation, fish, and wildlife are authorized under Section 8 of the Colorado River Storage Project Act (PL 84-485). Erosion control projects may fall under that section since they can help preserve the reservoir for the stated uses. If that section of the law does not apply, Congress could pass a Flaming Gorge Reservoir Eutrophication Control Act, which would be the equivalent of the Colorado River Basin Salinity Control Act (PL 93-320) and which would authorize the use of Upper Basin Funds for erosion control projects. Additional revenues from higher power rates and additional Federal appropriations to the Bureau of Reclamation could go into the fund to pay for the erosion control projects.

A second major user group of Flaming Gorge Reservoir is the recreationalist. This group is presently being charged for overnight camping in the Flaming Gorge National Recreation Area. This action is authorized under PL 90-540, which is the enabling act for Flaming Gorge Reservoir, and PL 93-303, which is the Land and Water Conservation Act. The collected fees can be used for development and administration of the recreation area's facilities.

In order to make recreationalists pay for erosion control projects, two amendments would have to be added to PL 90-540. Under one amendment, additional funds would be generated by charging users fees for boat launching or picnic use and for charging entrance fees into the recreation area. The second amendment would allow funds to be used for erosion control projects. At present, funds can be used only for development and administration of the recreation area's facilities.

Table 9-5

ALLOCATION OF COSTS, FLAMING GORGE UNIT

Use	Cost Allocation (1) ($1000's)
Power	$44,437 (57%)
Irrigation	16,662 (22%)
Recreation, fish, and wildlife	16,395 (21%)
Other	225 (0%)
Total Cost through June 30, 1976	$77,719 (100%)

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(1) Bureau of Reclamation. 1976. *Twentieth annual report, Colorado River Storage Project and participating projects, fiscal year 1976.*

The final user group is irrigators. Although no irrigation rights presently exist for the storage of water in Flaming Gorge Reservoir, the mechanism is available for charges for storage under the Colorado River Storage Project Act (PL 84-485). Revenues would go into the Upper Basin Fund and may be able to be used for erosion control projects.

WHO ACTS

The recommended initial action is a grazing environmental statement by BLM on Lower Muddy Creek and Little Muddy Creek. This study has been authorized and funded by BLM and is scheduled for completion in 1981 or 1982. The ongoing 208 agency in the area, the Wyoming Department of Environmental Quality, and EPA should monitor the progress of the study, be available as technical advisors, and encourage an emphasis on water quality management.

The results from the environmental statement on grazing in the Little Muddy and Muddy Creek drainages should be useful for defining the feasibility of range management in certain other critical areas. These areas include the Church Butte reach of Blacks Fork, Killpecker Creek, Salt Wells Creek, the Upper Bitter Creek reach, and the Lower Big Sandy River reach.

ENVIRONMENTAL AND SOCIAL IMPACTS

The BLM study itself would have no environmental or social impacts. Management alternatives proposed in the study may have significant environmental or social impacts; these would be addressed in that study.

OPTION 3
CHANNEL MODIFICATIONS IN MIDDLE AND LOWER BITTER CREEK TO CONTROL ACCELERATED EROSION

PROBLEM STATEMENT

The Middle and Lower Bitter Creek reaches are not in areas of moderate or heavy geologic erosion rates (see Figure 5-10). However, a rapidly deepening stream channel and sloughing banks are visual indicators that severe vertical erosion is occurring in these reaches. Furthermore, suspended solids concentrations as high as 43,600 mg/l have been recorded in these reaches. These suspended solids loadings are one of the factors for fisheries use impairment in the Lower Green River reach.

These two reaches contain the most concentrated human activity in the study area. The naturally meandering stream is pinched between the Union Pacific Railroad, Interstate 80, and Rock Springs urban development. Channel straightening has been a common practice where meanders in the river have endangered structures or private property. When channels are straightened, stream velocities are increased and vertical erosion can take place. This vertical erosion also encourages sloughing from the banks. The increased flow velocities may also have contributed to flood problems in Rock Springs. According to the Type IV study for the Green River Basin, annual flood damages attributed to Bitter Creek amount to $37,000.

There appears to be a serious accelerated erosion problem in the Middle and Lower Bitter Creek reaches due to channelization. With the growth of the Rock Springs area, this problem is likely to become even worse in the future. Undeveloped property along the creek below Rock Springs is presently being offered for development.

MANAGEMENT ACTION

The specific action is to carry out the necessary feasibility and predesign studies for channel stabilization using approaches such as construction of drop structures in the channel, channel bank protection, or channel reshaping. Drop structures are small dams or weirs placed at intervals in the stream to create a flatter gradient and to provide scour and erosion protection where the stored-up head is lost. Channel reshaping requires resloping banks so they are less easily eroded. Bank protection can be provided by riprap. The required study should determine the economic feasibility of using such approaches and should determine how many drop structures would be needed along the approximately 25 miles of stream in the Middle and Lower Bitter Creek reaches. The study should also look at the environmental impacts of each alternative. The study would include both the Middle and Lower Bitter Creek reaches, as well as all tributaries to them.

EXPECTED CONTAMINANT REDUCTION

Phosphorus loadings from geologic erosion in these two reaches were estimated empirically in Chapter 5. This source was estimated to contribute only 46 tons of phosphorus per year to Flaming Gorge Reservoir, which is less than 10 percent of the empirically estimated total loading to the reservoir. However, accelerated erosion due to channelization in these two reaches is also contributing phosphorus and sediment to the creek. The importance of this source is visually apparent but unquantifiable.

Better water quality monitoring in these two reaches can give a more precise measurement of the loadings from geologic and accelerated erosion. This monitoring should be a part of the feasibility study. For the purposes of this report, control of erosion in these reaches is assumed to reduce phosphorus loadings by as much as 46 tons per year. This value may be an underestimate because of the lack of information on loadings from accelerated erosion.

EXPECTED COST

Costs of this option are divided into two categories: the estimated cost for carrying out the necessary studies and the actual design and construction costs for channel modifications.

The cost for doing the studies could range from $20,000 to $200,000, depending upon the level at which the studies were carried out.

Costs for the drop structures themselves are estimated at about $8,000 each, assuming a 30-foot wide channel and a 5-foot drop per structure. Up to 100 such structures could be used in this project area. There are no anticipated annual O&M costs for this option.

Channel reshaping and bank protection is estimated at $128,000 per mile, based on a generalized channel cross section 30 feet wide and 20 feet deep, with 1-to-5 foot flow depth. If channel banks were reshaped to 1:1 slope with riprap on 2:1 slope for 5-foot flow depth, the above unit cost would apply. If 50 miles of channel were modified, the capital cost would be about $6.4 million. Annual O&M costs are estimated at 2.5 percent of the capital cost, or $160,000 per year. The annual cost over a 20-year period is $758,000 (assuming a 6-7/8 percent interest rate).

BENEFITS AND TO WHOM

Recreational users of the surface waters would benefit from reduced phosphorus levels and algae levels in the reservoirs, as would those who are in business associated with tourism and recreation. Property owners along Bitter Creek in the project area would benefit from increased channel stability and the lessened danger of bank erosion. In addition, with proper flood control modifications, benefits of up to $37,000 per year could be realized.

WHO PAYS

The costs of the feasibility studies may be financed through continuing 208 grants. It is assumed the BLM would not have the funds to do feasibility studies in the Bitter Creek drainage because of its efforts in the Muddy Creek drainage.

Those who may have caused local erosion through channel straightening in Middle and Lower Bitter Creek are Union Pacific Railroad, highway developers, and private developers. It is unlikely that any of these interests could be made accountable for previous erosion because none of them violated any erosion control laws and because previous water quality monitoring has not been adequate to allocate erosion loads to the various interests in the area. As an alternative, the costs associated with the design and construction of control structures could be paid for by those who benefit in a manner similar to that presented in the previous option.

WHO ACTS

The designated 208 agency could subcontract the feasibility study to BLM, DEQ, or a private consulting firm. The study could determine who should carry out the design and construction. Permits for any control structures would have to be obtained from the Corps of Engineers through the Dredge-and-Fill Permits Program (Section 404 of PL 92-500).

ENVIRONMENTAL AND SOCIAL IMPACTS

An environmental impact of this measure would be the reduction of phosphorus and consequent reduction of algae in the Flaming Gorge Reservoir system. Another positive environmental impact is the benefit to the stream corridor due to increased channel stability. Reduced erosion would result, and there would be less loss of land. A final benefit that could be built into this option is flood control for the Rock Springs area.

The Middle and Lower Bitter Creek reaches lie in a region of Mancos-type shales. Any projects which tend to increase ground water flows have the potential to significantly increase salinity. Flow detention basins may increase ground water flows through seepage. The salinity impacts of any action in these two reaches should be carefully investigated.

A social impact of this option is the need to involve a Federal agency (BLM) and the Union Pacific Railroad to jointly carry out the cooperative action. Union Pacific is involved because of the alternating ownership of land sections with BLM in much of the project area. With this ownership pattern, many of the drop structures could be on Union Pacific land.

OPTION 4

STRUCTURAL CONTROLS IN UPPER BITTER CREEK, MUDDY CREEK, LITTLE MUDDY CREEK AND KILLPECKER CREEK

PROBLEM STATEMENT

Option 2 considered range management in Lower Muddy Creek and Little Muddy Creek in order to control the high production of sediments and high phosphorus loadings in the two reaches. The political difficulties with that option were that it required range management and that only half of the lands were in public ownership, with most of the rest owned by Union Pacific Railorad.

MANAGEMENT ACTION

The option provides an alternative to Option 2 that may be politically more feasible. The difference is that this option is directed towards structural-type work on public lands as opposed to revegetation and fencing on public and private lands. This option considers the same reaches covered in Option 2, namely Lower Muddy Creek, Little Muddy Creek and Killpecker Creek. In addition, this option covers Upper Bitter Creek, where overgrazing is not a problem but where high production of sediments and high loadings of phosphorus occur.

This option requires feasibility studies on structural-type channel improvements for the slowing of erosion and off-line sedimentation ponds for the removal of sediment loads from the creeks.

EXPECTED CONTAMINANT REDUCTION

All reaches are in areas of moderate to heavy geologic erosion (see Figure 5-10). Therefore, erosion control is likely to produce significant reductions in sediment and phosphorus loads carried by the creeks in these areas. Empirical estimates of phosphorus loadings generated by general erosion show that erosion control can reduce phosphorus loadings from Upper Bitter Creek by as much as 70 tons per year and from Muddy Creek and Little Muddy Creek by as much as 121 tons per year.

Accelerated erosion is also occurring in Upper Bitter Creek and Lower Muddy Creek due to channelization. The railroad runs along much of Upper Bitter Creek and Lower Muddy Creek. Channelization has taken place in these reaches in order to protect the railroad bed from meanders in the two creeks. Accelerated vertical erosion and bank sloughing are caused by channelization in the study area. However, the impact of accelerated erosion on sediment and phosphorus loads in the two reaches is difficult to assess because of the lack of adequate water quality information.

EXPECTED COST

The costs of the structural controls would be determined as part of the feasibility studies. The cost of doing the studies for Upper Bitter Creek could range from $50,000 to $150,000, depending upon the degree of detail with which the study was done. If dams were part of the study, the cost would likely be higher due to the increased engineering investigations needed for dam sites. The study in the Little Muddy and Lower Muddy drainage would be included in the grazing environmental statement planned by BLM. No cost estimates have been made yet for that study.

Construction costs could be in the range of $800,000 for up to 100 drop structures to several million dollars with dams or extensive channel modifications.

BENEFITS AND TO WHOM

Those who benefit are those who use surface waters in the area for recreational purposes and those who are in business associated with recreation and tourism. Additional benefits may be gained for fisheries, which show use impairment due to high suspended solids concentrations in all three reaches considered under this option.

WHO PAYS

BLM would pay for the feasibility study in the Lower Muddy and Little Muddy. The funds for the feasibility study in Upper Bitter Creek would come out of the continuing 208 program. A means of financing the design and construction of the control structures is presented under Option 2.

WHO ACTS

BLM would carry out this option in the Lower Muddy and Little Muddy areas through the grazing environmental statement. The designated 208 agency would carry out the option in Upper Bitter Creek. If SWWQPA does not continue after the completion of this plan, either DEQ or the Wyoming Conservation Commission could take over the Upper Bitter Creek study. Technical assistance could be provided by SCS, BLM, and other agencies.

Permits for any structural controls would have to be obtained from the Corps of Engineers through the Dredge-and-Fill Program (Section 404 of PL 92-500).

ENVIRONMENTAL AND SOCIAL IMPACTS

There would be no impacts associated with the study itself, but the environmental impacts of the structural actions that could result would be those involved with construction of various facilities. As noted for the previous option, any projects which increase ground water flows may also increase salinity. The salinity impacts of any action should be carefully investigated.

The beneficial impacts would be reduced algae production in the Flaming Gorge Reservoir system and increased channel stability in the upper part of the basin involved.

A social impact would include the need to involve Union Pacific Railroad along with the Federal agency carrying out the necessary studies, since the railroad owns much land in both areas.

OPTION 5
IN-LAKE MANAGEMENT

PROBLEM STATEMENT

Excessive algal growth is causing use impairment on several reservoirs in the study area. The prominent example is Flaming Gorge Reservoir, where eutrophication may have caused detrimental changes in fish populations and where it has clogged waters and impaired recreational activities. Serious algal problems have also occurred in Woodruff Narrows Reservoir, where in-lake management techniques have been used in an attempt to alleviate the water quality problems. As shown on Figure 9-1, phosphorus concentrations in every reservoir in the study area exceeded the recommended water quality criterion. Therefore, the potential exists for undesirable algal growth in all reservoirs in the study. Only in Bear Lake, which lies just to the west of the study area and which receives inflow from the Bear River, are phosphorus concentrations in the surface water less than the criterion.

MANAGEMENT ACTION

The management alternatives discussed under this option would promise only short-term effects. However, they can provide a temporary reduction in algal populations and make a reservoir usable while phosphorus control techniques with long-term effects are being implemented. Because of the cost and potential environmental impacts, this option should be restricted to reservoirs with high recreational use and severe algal problems. The only reservoir to qualify under these conditions is Flaming Gorge Reservoir.

A series of small demonstration projects are recommended before any large-scale in-lake management program is initiated in Flaming Gorge Reservoir. As noted in the last section of this option, the environmental impacts of such a program are uncertain, but potentially severe. These potential impacts would have to be investigated in detail in an environmental impact statement before an in-lake management program would be allowed to take place.

In-reservoir management would be aimed at controlling excessive blooms of planktonic algae, the free-floating algae which clog up the surface waters of Flaming Gorge Reservoir. Few alternatives have been tested for control of planktonic algae in a large water body such as Flaming Gorge Reservoir. Alum has been used successfully for nutrient deactivation and copper sulfate has been used successfully as an algal toxin in some lakes. Fly ash has been tested on several small Indiana lakes and has also successfully removed phosphorus from the water.

EXPECTED CONTAMINANT REDUCTION

Alum treatment or fly ash treatment can remove phosphorus from the surface waters and make it unavailable for algal growth. Alum can quantitatively remove inorganic phosphorus, and therefore phosphorus concentrations can be reduced below the criterion if alum is applied when most of the phosphorus is in the inorganic state. This condition will probably occur in early spring before much algal growth has taken place. The removal capabilities of the fly ash depend on its chemical content and can be predicted only from bench tests.

Alum has the capability of binding the phosphorus up in the bottom muds forever. Phosphorus once removed by alum should not return to the waters except under unusual conditions of pH. Alum has been used effectively for removing phosphorus from wastewater and from small lakes.

Copper sulfate does not remove phosphorus from a lake system. It is an algacide which causes algae to break up and sink. Phosphorus is released from the dead algae and is available for uptake during future blooms. The reason for using an algicide is to destroy the immediate algal bloom, and not to prevent future ones.

Treatment by any of the three materials is directed at the symptoms rather than the causes of eutrophication. The most important cause is a high phosphorus loading to Flaming Gorge Reservoir from the tributaries. None of the treatment alternatives affects these phosphorus loadings to the reservoir.

EXPECTED COST

Assuming an area of about 800 acres is treated during the demonstration projects (about 2 percent of the reservoir surface), the cost would be about $163,000 per year. This breaks down as follows: manpower and barges, $40,000; alum, $120,000; copper sulfate, $3,000. The estimate is based on applying alum in spring to precipitate phosphorus and copper sulfate in fall to kill algae when blooms occur. The alum dose rate is 0.5 dry ton per acre. Additional expenses for transportation, water quality monitoring, bio assays, and data analysis could bring study costs to $250,000-300,000 per year.

BENEFITS AND TO WHOM

People who use Flaming Gorge Reservoir for recreational purposes would benefit from a reduction in algal weed growth. Services associated with recreational activities would also benefit.

WHO PAYS

Flaming Gorge Reservoir is located in a national recreation area. Therefore, the costs of treatment would probably be borne by the Federal Government. Some funding may be available through the "Clean Lakes" program, as provided by Section 314 of Public Law 92-500.

WHO ACTS

Action would be initiated by the U.S. Forest Service, the agency supervising the Flaming Gorge National Recreational Area. Assistance on in-lake treatment could be obtained from Environmental Protection Agency staff who have extensive experience in the field.

Because of the abundance of fly ash from the two power plants and coal-burning industries in the area, the Environmental Protection Agency should initiate a project on the feasibility of using the ash for phosphorus deactivation in the reservoir. This study could possibly be included in the "Clean Lakes" program.

ENVIRONMENTAL AND SOCIAL IMPACTS

Addition of alum, fly ash, or copper sulfate would increase salinity in the reservoir. The increase would be slight if treatment is applied only to the areas of concentrated algal growth in the Blacks Fork and Green River Arms. However, if phosphorus loadings to the reservoir are not controlled, areas of concentrated growth will expand, larger areas of treatment will be necessary, and salinity increases will grow in importance. The magnitude of the salinity increases from in-lake treatment could be estimated by EPA after experiments involving water and algae from the reservoir.

Treatment would add undesirable chemical species to the water, such as sulfate, copper, and other metals. The initial impact would occur in the sediment, where metals may reach toxic concentrations and affect bottom fauna and bottom feeders. The settled alum or fly ash floc would also affect the bottom fauna and bottom feeders.

Areas with no dissolved oxygen are likely to spread in the reservoir if treatment with copper sulfate is selected. Algae killed by copper sulfate would decompose and consume oxygen. Anoxic conditions restrict habitat availability for game fish and cause changes in bottom fauna.

Success with in-lake treatment can lead to the sometimes erroneous conclusion that the water quality problem has been solved. In many cases, in-lake treatment has only delayed or weakly disguised the problem.

OPTION 6
REQUIRE EROSION AND MANURE CONTROL FOR FARMING AND RANCHING ACTIVITIES

PROBLEM STATEMENT

Within the study area, agriculture has appeared to reduce sediment and phosphorus loadings. In areas where there is a lack of natural vegetation to stabilize the moderate to highly erodible soils, hay has been noted to have an excellent capability to stabilize these soils. Furthermore, chemical fertilizers are not widely used in the study area. The major application of phosphorus to irrigated lands is through manure. In Chapter 5, manure was estimated to contribute 11 percent of the empirical phosphorus load generated in the Green River Basin.

MANAGEMENT ACTION

Erosion control is estimated to have a small effect on sediment and phosphorus loading reductions to Flaming Gorge Reservoir. However, it can correct erosion problems on individual farms which can cost individual farmers considerable time and money. Unclogging of ditches and canals is a regular activity in many parts of the study area.

This 208 program has not been designed to address issues on the level of the individual farmer. The needs of the individual farmer can be identified through the conservation needs program conducted by the local conservation districts with the assistance of the SCS. The last *Wyoming Conservation Needs Inventory* was published in June, 1970. It identified 109,600 acres in the Green River Basin in Sublette County and the study area and 33,300 acres in the Blacks Fork Basin with erosion damages and with potentially feasible control programs. A new conservation needs inventory should be published soon to indicate the progress of conservation planning and to identify the critical areas or individual farms in the study area with respect to erosion.

Manure runoff was found in Chapter 5 to be the third largest phosphorus source to Flaming Gorge Reservoir. Two ways of reducing phosphorus loadings from manure runoff are either to reduce the number of animals through grazing permit restrictions or to move animals away from the highly erodible areas along streams. The first alternative would have severe economic and social consequences. The second alternative is probably more feasible, although probably still difficult to implement. The actions associated with this alternative have been covered under Option 2 for the Lower Muddy and Little Muddy areas. The same actions would be used in other areas of animal concentrations as listed on Table 9-3.

Manure storage facilities are not a viable alternative in the study area because manure controls must be placed on range cattle and sheep. These animals are generally not confined to small areas. Manure storage facilities are more justifiable for dairy herds and feedlots.

EXPECTED CONTAMINANT REDUCTION

Implementation of conservation plans may reduce phosphorus loadings to Flaming Gorge Reservoir from erosion by up to 3 tons per year and from manure runoff by up to 65 tons per year.

EXPECTED COST

Costs for conservation planning would be borne by the individual farmers. Technical assistance at no cost to the individual farmer can be received from SCS. Costs for conservation planning have not been estimated in this study.

BENEFITS AND TO WHOM

The benefits from erosion control would be gained by individual farmers through reduced time and money spent in cleaning irrigation ditches and canals. Benefits from manure control may include reduced algal growth in Flaming Gorge Reservoir and lower fecal coliform concentrations in the area's streams.

WHO PAYS

Although costs would be borne by individual farmers, Federal cost-sharing funds are available from the Agricultural Stabilization and Conservation Service for erosion control. Continuous 208 planning may also be able to provide funds for some of the capital costs of erosion control and manure control.

WHO ACTS

Conservation planning is a voluntary program and therefore is initiated by the individual farmers. The Wyoming State Conservation Commission has been designated the statewide management agency for agricultural nonpoint source pollution and would be the logical lead agency in the promotion of the conservation needs program in the study area.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental impacts of conservation planning are significant and positive for the individual farmer. The social impacts are minimized because of the voluntary nature of the conservation planning program.

OPTION 7
REQUIRE EROSION CONTROL FOR ALL CONSTRUCTION AND MINING ACTIVITIES

PROBLEM STATEMENT

Accelerated erosion was shown in Chapter 5 to be a likely cause of some fisheries use impairment in the study area. However, its contribution to phosphorus loadings to Flaming Gorge Reservoir appears to be small. In the future, accelerated erosion from construction, recreational vehicle use, and channelization is likely to increase because of the rapid growth predicted for the area. Therefore, this is the proper time to clarify existing erosion control ordinances and propose new ones, if needed.

MANAGEMENT ACTION

The activities which have the potential to cause severe accelerated erosion in the study area are mining and related activities, highway construction, and residential and industrial building construction. All of these activities are related to the expected boom in minerals and energy development in the study area. This 208 Plan has borrowed extensively from the work done by the Wyoming Highway Department, the Department of Environmental Quality, and the Powder River Areawide Planning Organization (PRAPO) in order to formulate a program to control future erosion from the activities listed above.

A management framework for mining has been developed by PRAPO and the Water Resources Research Institute (WRRI) in order to satisfy Section 208 of the Water Pollution Control Act of 1972. The entire management plan and the rationale for it are contained in a draft report, entitled "Water Quality Determinations, Mined Lands Areas, Northeastern Wyoming," and a companion document, "Assessment Report and Recommendations: PRAPO Planning Area." In summary, the important points in the overall program for pollution control in mining are given below:

- The establishment of sound data collection programs. These programs should generate information which properly defines water quality conditions and potentials at a proposed site.
- The site evaluation which attempts to define the pollution potential of a site as well as an area's susceptibility to the problem.
- The Water Resources Report. Prepared by the regulatory agencies from information provided by the operators, this report publicly presents an itemization of the important water resources/quality factors for the given site. (This report would appear to be unnecessary if an environmental impact statement were being written.)
- The preparation of a pollution control plan by the operator which addresses each of the potential sources of pollution identified

in the Water Resources Report. This plan would be submitted with the mining and reclamation plans and would be subject to the same type of review and public input.

- The establishment of re-evaluation programs which generate specific monitoring data to use in determining what alterations, if any, are necessary to the mining, reclamation, and pollution control plans.

It is recommended that the regulatory agencies evaluate this program.

The Wyoming Highway Department and the Department of Environmental Quality are developing a management plan for control of erosion from construction. The second draft of this plan is contained in Appendix C. It is recommended that the parts of that plan appropriate to construction of homes, offices, and industrial complexes be considered for adoption as part of the building permits program. Of particular concern should be the control of impacts caused by runoff increases and channelization.

EXPECTED CONTAMINANT REDUCTION

Implementation of the management plans for mining and construction should control future local erosion and mitigate the impacts on water quality of future energy development in the study area. This management option is not aimed so much at reduction in existing sediment and phosphorus loadings, but a control of the considerably larger loadings predicted for the future.

OPTION 8
REQUIRE CONSIDERATION OF WATER QUALITY IMPACTS OF WATER DEVELOPMENT PROJECTS

PROBLEM STATEMENT

Common current practice is to make multiple use of water development projects. In the past the impact of existing water quality on multiple use has often been considered; but changes in water quality have often not been projected, and these changes may be capable of eliminating one or more of the planned uses. Even if those projections were made, the project may still have been sold to the public without adequately describing potential future water quality problems.

An example of a water quality problem that developed as a result of a water resource development project is the eutrophication problem in Flaming Gorge Reservoir. Enough information was available in the literature by the early 1960's to alert people to the potential for eutrophication in the reservoir. Before construction, water quality monitoring should have been done to better define this potential.

The construction of a dam and formation of a pool of water at the site of Flaming Gorge Reservoir has resulted in the accumulation of phosphorus and other nutrients to the level where water quality problems exist in the Green River system that did not exist before. These water quality problems are specifically the growth of algae and other aquatic plants. People have become accustomed to using Flaming Gorge Reservoir for boating, water skiing, fishing, and other recreational activities but are increasingly disturbed by the deteriorating quality of water. Numerous people have complained about the quantity and extent of algae blooms in the reservoir each summer and people are commenting on the fact that it appears the algae is taking over more and more of the reservoir from the upstream toward the downstream end. Investigations in this 208 study have shown that phosphorus levels in the reservoir system are probably not high enough to produce an algae problem in a free-flowing stream, but are high enough to produce algae problems in a reservoir.

MANAGEMENT ACTION

The management action proposed under this option has nothing to do with existing water development projects such as Flaming Gorge Reservoir but is directed toward future projects. The management action is to do adequate studies of future water quality conditions prior to undertaking any water resource development projects and to take necessary steps to reduce potential problems where feasible, or at least to warn the public about the potential for problems. An agency should be charged with the responsibility to carry out a review of all projects. At the State level, the Interdepartmental Water Conference (IDWC) is an excellent medium for the exchange of information on both the quantity and quality of water considered for development.

EXPECTED CONTAMINANT REDUCTION

Reductions in phosphorus due to the above management action will depend on the specific proposed projects. However, if the intent of this management action is adhered to religiously, eutrophication problems can be avoided or overcome. The intent of this management action is not to reduce phosphorus loadings to a particular reservoir, but to aid in the proper selection of a location for any new reservoir which is projected to have substantial recreational benefits. A suitable location is either where existing and projected phosphorus loadings are below levels discussed at the beginning of this chapter, or where phosphorus loadings originate primarily from easily controllable point sources. Even if a water resource project is developed that has the potential for water quality problems, at least the people would have been warned.

EXPECTED COST

The expected cost for this management action can only be determined once the proposed water resource development projects are identified.

BENEFITS AND TO WHOM

Consideration of possible water quality impacts of developments may avoid such problems as eutrophication. Where natural phosphorus levels are quite high, there may be no way to avoid eutrophication except by not building the water resource projects. For other areas, the public should be made aware of the possibility for eutrophication, the expense for controlling this problem, and the extent it can be controlled.

WHO PAYS

The financial source for this management option would depend on the proposed projects.

WHO ACTS

Wyoming DEQ would be responsible for ensuring the proper evaluation of future water quality conditions associated with any proposed water development projects in the State. The State Engineer and/or the Wyoming Water Planning Office would be directed to also evaluate water quality factors when the project is presented to them.

If one of the evaluation criteria for a water resources development project is the benefit-cost ratio, it must be assured that all costs of ensuring the planned benefits against water quality impacts are included in the calculation of the ratio. The transfer of water quality and water quantity information needed to make a complete evaluation of a water resources development project can be accomplished through the IDWC.

Federal facilities are now required to meet State water quality standards, according to Section 313 of Public Law 92-500 and Executive Order 11752 from the EPA. Both DEQ and EPA could examine the water quality impacts of a new Federal project to see if the requirements of the executive order can be met.

The construction of a water resources development project with severe water quality impact can be blocked by EPA or the Corps of Engineers through the dredge-and-fill permit process. Section 404 of the 1972 Clean Water Act (PL 92-500) authorizes EPA to "prohibit the specification of any defined areas as a disposal site" for dredged or fill material if "the discharge... will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas... (and) wildlife or recreational areas." The Corps of Engineers must approve the dredge-and-fill permit.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental implications of making a proper evaluation of future water quality impacts would be possibly to reduce future eutrophic conditions in reservoirs or to avoid building reservoirs that might become eutrophic. However, not building the reservoir would eliminate the potential socioeconomic benefits associated with recreational activities.

These tradeoffs involved in implementing a proposed project must be carefully considered.

OPTION 9
STUDY PHOSPHORUS CONTROL FOR TRIBUTARIES TO PALISADES RESERVOIR

PROBLEM STATEMENT

In Chapter 5 of the draft Technical Report, the phosphorus situation with regard to Palisades Reservoir and the Snake River tributaries was described. Both this 208 and the Teton County 208 found that the water quality problem lies in both 208 areas as well as in parts of Idaho. No one state or 208 agency seems to have total jurisdiction over all the tributaries to Palisades Reservoir.

MANAGEMENT ACTION

As shown on Figure 9-1, the phosphorus loadings to Palisades Reservoir have the potential for causing eutrophication in the reservoir. A study should be undertaken specifically for Palisades Reservoir and its tributaries to determine appropriate methods for controlling eutrophication in the reservoir.

EXPECTED CONTAMINANT REDUCTION

The amount of potential phosphate reduction would be determined in the study.

EXPECTED COST

The cost of performing a study of Palisades Reservoir could range from as little as $20,000 for a fairly cursory examination to as much as $200,000, which would include very detailed modeling.

BENEFITS AND TO WHOM

The benefits associated with the study would be a potential reduction in the eutrophic status of Palisades Reservoir. This reduction would benefit the recreational users of the reservoir and the tourist industry.

WHO PAYS

The study would be paid for by the taxpayers of the United States, specifically of the States of Wyoming and Idaho.

WHO ACTS

It is proposed that the study be done under the jursidiction of EPA since it would require considering activities and streams located in both Wyoming and Idaho. It is further recommended that both the States of Idaho and Wyoming participate in the study and support it. Additionally, the Teton County 208 and the SWWQPA 208 planners could support the study with the data reported in their respective 208 documents.

ENVIRONMENTAL AND SOCIAL IMPACTS

The study could result in actions to reduce the amount of phosphorus in Palisades Reservoir and thereby reduce the amount of algae and undesirable aquatic growths.

The social impacts of the study would be to foster a cooperative effort involving two states and the Federal Government.

OPTION 10
CONVERT TO NONPHOSPHATE DETERGENTS

PROBLEM STATEMENT

Some of the phosphorus entering streams originates from municipal, commercial, and industrial use of detergents containing phosphates. In the study area at the present time, treatment facilities do not have processes for reducing or treating phosphorus in the effluent. Providing additional treatment at the treatment facilities would reduce the phosphorus levels but would also add to the cost of treatment.

MANAGEMENT ACTION

As an alternative to treating phosphorus in wastewater, communities or counties or the State could enact ordinances or legislation to prohibit the sale and use of phosphate detergents in the area of jurisdiction.

EXPECTED CONTAMINANT REDUCTION

The total estimated phosphorus discharged from point sources and the estimated amounts from other sources were listed on Table 5-12. About 50 percent of the total phosphorus loads is attributable to the use of phosphate-containing detergents. This estimate is based on application of data from sources outside the study area. Thus, this information should be taken as only approximate.

At 50 percent, it can be seen that eliminating phosphorus detergents would reduce phosphorus loads entering Flaming Gorge Reservoir by 30 tons each year.

EXPECTED COST

There are various industrial, commercial, and residential grade nonphosphate detergents available on the market. Their prices are comparable to those for typical phosphate detergents. Users of nonphosphate detergents report that their effectiveness per pound is somewhat less than phosphate detergents. Cost, therefore, for detergents alone are likely to be higher. The Soap and Detergent Association reports that the costs to consumers from having to use nonphosphate detergents might range from $5 to $236 per household per year. The lower value includes cost differences between the products and increased washing machine repairs. The higher value includes effects of more hot water use and more frequent garment replacements (the Soap and Detergent Association, June 1977). For the total study area population of about 60,000 persons, the total cost of converting to nonphosphate detergents could range from $300,000 to $14,160,000 per year.

BENEFITS AND TO WHOM

The benefits of converting to nonphosphate detergents are largely to the recreational users of various water bodies, such as Flaming Gorge Reservoir, and the tourist industry.

WHO PAYS

A transition period would be provided as part of the control action so that existing stocks of phosphate detergents could be used up prior to conversion. After this period, the consumers of nonphosphate detergents would essentially be paying for the management option.

WHO ACTS

Any one of the four levels of government could implement this option--local, county, state, or Federal. If the Federal Government intended to take this action, it probably would have by now. The State Legislature is probably the most appropriate body to act, but it probably will not because not all parts of the State are necessarily affected by the use of phosphate detergents. Because the problem is local in cause and effect, county governments might consider action on a proposal to eliminate the sale and use of phosphate detergents within their jurisdiction. Should any county in the study area not require the conversion to nonphosphate detergents, a local community might act on its own within its jurisdiction.

ENVIRONMENTAL AND SOCIAL IMPACTS

This action would result in an estimated 6 percent reduction of the levels of phosphorus discharged to Flaming Gorge Reservoir. This range reflects the fact that not all users have a discharge and that some food industry users may not have another product available. The potential positive impact would be a reduction in eutrophic levels in various reservoirs in the study area. Sufficient natural phosphorus is present in stream systems throughout the area to act as a nutrient for beneficial aquatic growths.

The social consequences of this action would be the potential alienation of the public against the implementing governmental agency. In addition, there would be the impact of reduced sales by the producers and suppliers of phosphate detergents. However, those losses could be offset by the production and sales of nonphosphate detergents. Finally, as mentioned earlier, the consumers may have extra expenses resulting from the use of nonphosphorus detergents.

OPTION 11
ADOPT PHOSPHORUS STANDARDS FOR FLAMING GORGE RESERVOIR

PROBLEM STATEMENT

Flaming Gorge Reservoir is eutrophic in the two arms and mestrophic in the main body. Algal growth is excessive in the two arms, and excessive algal growth is beginning to spread down the reservoir from the two arms. The existing phosphorus loadings are capable of continuing eutrophic conditions in the two arms and may be capable of producing eutrophic conditions throughout the main body of the reservoir.

If the reservoir becomes eutrophic throughout, the fish population will likely change from primarily game fish to primarily nongame fish, and recreational opportunities in the reservoir will be lost. Recreation related to Flaming Gorge Reservoir is an estimated $2 million per year industry in Southwestern Wyoming. Because of the importance of recreation in Flaming Gorge Reservoir, EPA has designated the reservoir as the most important candidate for cleanup in Wyoming.

MANAGEMENT ACTION

Instream phosphorus standards are necessary in order to formulate wasteload allocations and control phosphorus discharges to the reservoir. Two critical total phosphorus levels in the surface waters have been defined: 0.080 mg/l, which marks the maximum level for permissible conditions, and 0.030 mg/l, which marks the maximum level for desirable conditions. Either level will be difficult to meet on a continuous basis in the two arms by control of phosphorus loadings. For example, to attain permissible conditions in the two arms would require an estimated 75 percent reduction in phosphorus loadings from Green River and an 85 percent reduction from Blacks Fork. This degree of reduction is probably not possible when so much of the load comes from natural, nonpoint sources.

A permissible level of 0.080 mg/l or less at all times may be attainable in the two arms by a combination of phosphorus controls and in-lake management, however. In-lake techniques are described under Option 6. Management of phosphorus in the two arms will not only improve conditions in the arms themselves, but also control phosphorus loadings from the two arms to the main body of the reservoir. The two arms are estimated to deliver 60 percent of the total phosphorus loading to the main body.

The permissible level may be a reasonably attainable goal in the two arms. Therefore, it is recommended that DEQ consider for adoption an instream phosphorus standard in the two arms of 0.080 mg/l total phosphorus in the surface waters. A program to meet this standard is described in Chapter 11.

As shown on Figure 9-1, stations in the main body of the reservoir have either permissible conditions (F3) or desirable conditions (F4-F9). In order to attain desirable conditions throughout the main body of the reservoir, phosphorus loadings to the main body will have to be reduced by an estimated

100-135 tons per year (50-70 percent). Control of phosphorus in the two arms will go part of the way toward the desired reduction. Other phosphorus controls may be done in Henrys Fork, Sage Creek, Current Creek, or other tributaries, as required. Desirable conditions appear to be an attainable goal in the main body of the reservoir. Therefore, it is recommended that DEQ consider for adoption a standard of 0.030 mg/l total phosphorus in the surface waters in the main body of the reservoir. A program to meet this standard is described in Chapter 11.

EXPECTED CONTAMINANT REDUCTION

The standards are designed to encourage permissible conditions in the two arms and desirable conditions in the reservoir.

EXPECTED COST

Costs for developing phosphorus standards have not been estimated. However, these costs would probably be small compared to the costs of the phosphorus control program or the benefits from it.

BENEFITS AND TO WHOM

The largest benefits would go to recreationalists and services supporting recreation in Flaming Gorge Reservoir. Some additional benefits may be gained for fisheries in the streams because of erosion controls needed to meet the phosphorus standards.

WHO PAYS

DEQ would incur costs in the development and enforcement of phosphorus standards. These costs are difficult to assess.

WHO ACTS

DEQ would adopt phosphorus standards for Flaming Gorge Reservoir. Authorization for this action comes under the Wyoming Environmental Quality Act, 1973 Session Laws, Chapter 250, Section 1.

DEPAD would review any public or private action which may increase significantly the phosphorus concentrations in the reservoir. This department has authority for control over the physical and economic resources of the State (WS 9-160.19) and for study of private activities which may have an effect on public interest (WS 9-160.29(a)(iv).

OPTION 12
NO ACTION

PROBLEM STATEMENT

Flaming Gorge Reservoir is a valuable recreational resource in Southwestern Wyoming. However, its recreational value is being impaired because of excessive algal growths. Previous options have considered ways to reduce algal growths through the control of phosphorus. This option presents a different philosophical approach toward the management of the environment.

The reservoir is an artificial impoundment constructed for storage and multipurpose use of Upper Basin water. Without the construction of the dam and reservoir, eutrophication probably never would have become a serious problem in the area because there would have been relatively few recreationalists in the area and because there would have been no still-water habitat for the troublesome blue-green algae. But the reservoir has attracted several hundred thousand recreationalists each year, and the still-water environment in the reservoir has provided the proper habitat for the growth of the free-floating blue-green algae causing the problem.

If man-induced activities were causing the eutrophication problem, there might be a justification for controlling phosphorus loadings from these activities in order to provide a better recreational environment. However, as shown in Chapter 5, 58 percent of the annual phosphorus loading to the two arms (332 of 575 tons) is attributed to geologic erosion, which is affected very little by man. If man had not built any towns in the study area, or built any roads, or cultivated any lands, or grazed any cattle and sheep, there would still have been a eutrophication problem in the reservoir due to nutrient loadings from natural erosion.

This point raises the philosophical question of whether man should attempt to control natural erosion processes for the benefit of an artificial impoundment. Phosphorus controls will require drop structures, riprap, sedimentation basins, range controls, addition of chemicals to the reservoir, and other measures potentially disruptive to the natural and human environments. The environmental, social, and economic costs of phosphorus controls may outweigh the benefits in the reservoir.

The importance of natural phosphorus loadings also raises a question about the effectiveness of man to control them. The existing natural erosion rates have developed over thousands of years. To control these dynamic processes in a relatively short time span within a desert environment may be a costly and difficult task

MANAGEMENT ACTION

The importance of Flaming Gorge Reservoir as a recreational resource is undeniable. The loss of the reservoir to recreation may be delayed by in-lake management techniques described under Option 6. In the meantime, alternative recreational sites can be developed. These sites may include Bear Lake and other water bodies where management of man-induced phosphorus loadings can maintain oligotrophic or mesotrophic conditions. New recreational sites must be examined carefully to ensure that water quality will accommodate the planned recreational activities. This concern is covered more fully in Option 8.

EXPECTED CONTAMINANT REDUCTION

Some control over algal growth could be exercised by in-lake management. However, there would be no effort to reduce phosphorus loadings to the reservoir.

EXPECTED COST

The cost of this option would be the eventual loss of game fishing and other recreational opportunities in the reservoir and the associated economic losses to the recreation and tourism industry in Southwestern Wyoming.

BENEFITS AND TO WHOM

The benefits are the elimination of costs for phosphorus controls on municipal treatment plants, on rangelands, along railroads and roads, etc.

WHO PAYS

The only direct costs of this option may be some for in-lake management. These costs are covered in Option 5.

WHO ACTS

Only Option 8, and perhaps Option 5, would be exercised in conjuction with this option. Therefore, the actors under this option would be the same as those under Option 8 and perhaps Option 5. These actors include DEQ, the State Engineer, the Wyoming Water Planning Program, the Bureau of Reclamation, and others.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental impacts would be the eventual loss of the reservoir to eutrophication. Social impacts may include a loss of jobs in the recreation and tourist industry, a loss in area pride, and others.

Chapter 10
CONTROLS FOR OTHER ISSUES

A number of other issues besides the control of salinity and phosphorus have emerged from this 208 study as being important. The 11 options which address other issues are listed on Table 10-1.

The first six options consider solutions to the fecal coliform and dissolved oxygen problems identified in Chapter 5. The relationship between these problems, sources, and management options is shown on Table 10-2.

The next set of options addresses water quality standards for the area. Previous discussion on water quality criteria and standards has occurred in Chapter 2, in Option 7 of Chapter 8, and in Option 11 of Chapter 9. The three options on water quality standards in this chapter involve issues related to water quality standards but not specifically related to salinity and phosphorus.

The final two options address institutional issues in the study area. One concerns institutional management of septic tanks and point sources, while the other concerns the future of 208 planning in the study area.

Table 10-1

OTHER WATER QUALITY ISSUES

Fecal Coliform and Dissolved Oxygen Problems

Option 1: Management of Individual Waste Systems
Option 2: Alternatives to Option 1 for Bridger Valley
Option 3: Point Source Reductions of Fecal Coliform

  Suboption A: 208 Goal
  Suboption B: National Goal

Option 4: Point Source Reductions of BOD
Option 5: Eutrophication Controls to Increase Dissolved Oxygen Levels
Option 6: Manure Control

Water Quality Standards

Option 7: Use-Based Approach to Water Quality
Option 8: Development of Heavy Metals Standards
Option 9: Water Quality Monitoring

Institutional Issues

Option 10: Clarification of Institutional Responsibilities for Sewage Treatment
Option 11: Identification of Ongoing 208 Planning Agency

Table 10-2

OTHER PRINCIPAL CONTAMINANT SOURCES AND MANAGEMENT OPTIONS

Use	Constituent	Reach with Water Quality Problem	Source	Location	Management Option
Secondary Contact Recreation	Fecal Coliform	Lower Green River	Municipal wastewater discharges	Rock Springs Green River	3
		Bitter Creek	Municipal wastewater discharges	Rock Springs South Superior Husky Truck Stop	3
		Salt Wells Creek	Manure runoff Septic tanks	Salt Wells Creek drainage	1, 6
		Killpecker Creek	Manure runoff Septic tanks	Killpecker Creek drainage Killpecker Creek drainage	1, 6
		Lower Smiths Fork	Municipal wastewater discharges Manure runoff Septic tanks	Mountain View Bridger Valley Bridger Valley	1, 2, 3, 6
		Middle Hams Fork	Municipal wastewater discharges	Kemmerer-Diamondville	3
Primary Contact Recreation	Fecal Coliform	Border Reach, Bear River[1]	?	?	7
		Green River (#13, #15, #16, #17)	Manure runoff	Green River drainage	6
		Lower Green River (#18)	Municipal wastewater discharges	Rock Springs Green River	3
		Upper Big Sandy[1]	Manure runoff	Big Sandy drainage	6, 7
		Blacks Fork, Lyman to Little America[1]	Municipal wastewater discharges	Kemmerer-Diamondville Granger Lyman	1, 2, 3, 6, 7
			Manure runoff Septic tanks	Mountain View Bridger Valley Bridger Valley	
		Middle Hams Fork[1]	Municipal wastewater discharges	Kemmerer-Diamondville	3, 7
Fishery	Dissolved Oxygen	Snake River	Municipal wastewater discharges (BOD_5)	Outside study area	4, 5
			Principal phosphorus sources	Outside study area	
		Green River, Lower Reach	Municipal wastewater discharges (BOD_5)	Green River Husky Truck Stop South Superior	4, 5
			Principal phosphorus sources	See Table 5-13	
		Hams Fork, Middle and Lower	Municipal wastewater discharges (BOD_5, phosphorus)	Kemmerer-Diamondville	4, 5

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[1] Under national goal only.

OPTION 1
MANAGEMENT OF INDIVIDUAL WASTE TREATMENT AND DISPOSAL

PROBLEM STATEMENT

In areas such as portions of Bridger Valley and in the urbanizing areas around Rock Springs and Green River, much of the development has occurred using individual waste disposal methods such as septic tanks and drain fields. Most of the trailer parks and some of the subdivisions have developed central waste disposal methods for the individual development, but many septic tanks still exist. There are about 6,000 persons on septic tank units now throughout the three-county area, and between 200 and 400 are likely to be added each year for the foreseeable future.

Because septic tanks are so commonly used and because they are buried in the ground out of sight, they are frequently taken for granted by homeowners. But a septic tank drain field system is a fairly complex treatment system designed to handle potentially harmful wastes. Proper design, installation, and operation of such systems is extremely important for the protection of public health because contaminants from the septic tank drain field system can enter water supplies in shallow wells and cause disease or sickness in drinking water.

At present, Sweetwater, Lincoln, and Uinta Counties have no programs for the management of individual waste systems. The three counties rely primarily on the Wyoming Department of Environmental Quality (DEQ) inspector who has jurisdiction over Albany, Carbon, Sweetwater, Uinta, Lincoln, and Teton Counties. With one State inspector for all that area, obviously not much can be done except respond to urgent problems. Sweetwater County has a sanitarian who responds to problems on a variety of subjects having to do with public health; however, his effectiveness is hampered by a lack of authority to inspect and enforce.

Records kept by the Sweetwater County Sanitarian from January 1975 through July 1977 (33 Months) show about on-half of all complaints received (98 out of 200) pertained to sewage, usually septic tanks. He has travelled some 25,000 miles in that period while making up to 250 field inspections. He estimates that perhaps again as many problems exist that he has no knowledge of, largely because many people do not know whom to call. The situation in the other two counties is worse because the State inspector's office is even further away and so he is not as likely to be called.

Adequate State regulations exist for the management of individual waste systems, and the State has encouraged individual counties in Wyoming to take on the responsibility for managing this program. No funds have been made available, however, at either the State or county level for implementing such a program.

MANAGEMENT ACTION

Each of the counties could pass an ordinance establishing an individual waste disposal management program for new units. This program could consist of three parts: (1) review of design; (2) inspection during construction; and (3) periodic inspection during subsequent operation.

The county can adopt the State standards or develop its own standards for proper design of individual waste disposal systems and then require that all systems be designed according to those standards. The State standards are outlined in Chapter III of the *Wyoming Water Quality Rules and Regulations*. Amplification of the standards and implementation procedures are presented in the *Manual of Septic Tank Practice* by the U.S. Public Health Service and in the *Recommended Standards for Sewage Works* developed by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers.

Within the State standards is wording which allows the counties to make design criteria stricter than those presented in the State standards. The 208 Plan for Teton County, Wyoming, has placed a major emphasis on septic tanks and has developed stricter criteria suitable for that county. These criteria may be valuable as guidelines for design of septic tanks in Sweetwater, Lincoln, and Uinta Counties.

During construction of each waste disposal system, the county sanitarian could inspect the site to make sure that the installation is in keeping with the requirements of the design. The inspections would ensure that each individual system is set up in the beginning to maximize treatment capability and protect public health. In the 208 Plan for Teton County, it was noted that contractors and homeowners often sought to cut expenses in the construction of septic tank systems and in the process fell short of meeting the State requirements. Performance bonds posted by the contractor could be required to guarantee the system against substandard workmanship for a period up to 3 years.

To make sure that the intention of good design and installation is carried out in practice, each new septic tank would be inspected by a qualified county sanitarian or other official on a regular interval between 1 and 10 years, depending upon factors mentioned below. Inspectors would check that the drain field was operating properly so that liquid was not coming to the surface and would also check the depth of sludge relative to the depth of liquid in the septic tank itself. Treatment efficiencies are greatly impaired in septic tanks when sludge reaches a depth greater than one-third of the liquid depth. A maintenance permit would be issued upon completion of the inspection. A model maintenance permit is presented in Appendix D.

Factors governing the frequency of re-inspection would include the following:

- Where septic tanks are used for houses or other uses on more than 2 acres of land, operating inspections need only be done once every 10 years because the risk and likelihood of creating public health problems is very low.

- Where soil conditions and proper design have been shown to be effective in preventing risk of contamination from septic tank operations, re-inspections need only occur at periods between 5 and 10 years, as the county sanitarian judges most appropriate.

- For new installations in relatively poor soils or in high density locations, re-inspections should take place every 3 years until the sanitarian is satisfied that a longer period of time is suitable for that particular installation.

- Septic tank systems which use pumps, blowers or other mechanical devices should be inspected once a year because of the greater likelihood of failure.

The county sanitarian or other qualified official would develop guidelines for each of the three parts of the management program to ensure that everyone involved understands the requirements.

The program described above would apply only to new septic tank systems. Some program should also be developed for existing septic tank systems. Bacterial problems in ground waters and surface waters of the study area have been linked in part in Chapter 5 to failure of existing septic tank systems, particularly in Bridger Valley.

The inspection program described for new systems would be difficult to apply to existing systems. Most of the existing systems do not have easy access in order to determine liquid depths, and in many cases the locations of the septic tanks are unknown. Costs to locate septic tanks and install observation ports would be considered excessive by the owners and the counties.

What is recommended for existing septic tank systems is to improve the effectiveness of the present program through an increase in manpower and water quality monitoring. The present staff at the county level cannot handle the number of complaints related to septic tanks and the number of field inspections to effectively enforce the present program. Additional staff could relieve this overload.

A primary responsibility of the new staff should be the collection of more water quality data in areas where failures of septic tanks have occurred or where failures are possible because of soil types, ground water levels, and densities. Parameters that should be monitored include fecal coliform, fecal strep, nitrate and chloride. These data could be used to indicate the presence of water quality problems and facilitate the enforcement of control measures to relieve the problems.

EXPECTED CONTAMINANT REDUCTION

The program described above should eliminate all water quality problems associated with future septic tanks. However, water quality problems associated with existing septic tanks will continue to occur, although at a decreasing rate as failing septic tanks are better maintained or replaced.

The greatest water quality improvement will be less widespread bacterial contamination of domestic well water and surface waters. Some reduction in phosphorus loadings from septic tanks will also be achieved; however, because septic tanks have been estimated to contribute only three tons of phosphorus per year to Flaming Gorge Reservoir, the phosphorus loading reductions achievable under this option will be insignificant compared to those achievable under options presented in Chapter 9.

EXPECTED COSTS

Costs will be incurred by the owners and by the regulating agencies during design and construction and during operation of the system. Additional costs incurred under this option during the design and construction phase will result from inspections, performance bonds, and any design changes requested by the inspector. Additional costs incurred during operation will result from sludge pumping and disposal, maintenance permit inspections, and water quality monitoring.

The estimated cost of one inspection visit during design and construction is $60; this calculation is based on two inspections per day by each inspector. Three inspections are recommended during design and construction, one just before the commencement of construction, one during construction, and one at the completion of construction. Thus, inspections during design and construction are estimated to cost a total of $180 per unit.

The performance bond would be adequate to replace the septic tank system if it is not built to design specifications. The interest on a $5,000 bond would be approximately $40. The cost of paperwork associated with the bonding will vary widely, but an estimated cost of $25 has been assumed.

Development and enforcement of proper design and installation standards for individual waste disposal systems will add to the cost of building such a system. For example, requirements for some installations are likely to require larger drain fields for septic tanks than are now used, or certain installations may have soil conditions that would require installing two drain fields and alternating use of them on an annual basis. Because of the extreme variability of these potential additional costs, no estimate can be made of them at this time.

One design change that will be required of all new septic tanks under this option is a permanent access to the tanks for observation of liquid levels and sludge pumping. This access can be accomplished by the installation of a 24-inch cast iron manhole frame and grate. The cost of this design change is estimated at approximately $50 per unit.

More frequent sludge pumping and disposal during the operation phase will be required under this option. The annualized cost of sludge pumping and disposal is estimated at $20. In other words, if sludge is pumped from a particular unit every 3 years, the total cost of the pumping and disposal would be 3x$20=$60.

Maintenance permit inspections would be required every 1 to 10 years, depending on the factors described in an earlier section. The estimated cost of one maintenance inspection and permit processing is $40. Thus, the estimated annual cost is $4-40.

Water quality monitoring programs would have to be designed on a case by case basis to ensure enough data are collected in order to identify water quality problems. Four constituents would be monitored at an average cost of $10 per constituent analysis. The locations of sampling stations and the frequency of sampling would depend on the number of existing stations and wells in the particular area and the potential for water quality problems based on soils types, ground water levels, and density and design of septic tank systems.

BENEFITS AND TO WHOM

The public as a whole would be protected against public health hazards through implementation of an individual waste disposal management program. The public health hazards are primarily those associated with bacterial contamination of well drinking water supplies and of surface waters used for drinking water supplies and primary and secondary contact recreation.

WHO PAYS

The sources of revenue for this option are listed on Table 10-3. The septic tank program is designed to the self-supporting except for (1) some property tax revenue applied to the cost of inspections during design and construction and (2) some property tax revenue or State funds used to support the water quality monitoring program. Design-and-construction permit fee income will vary widely because of the wide fluctuations in the numbers of housing starts from season to season and year to year; thus, it is recommended that inspections during design and construction be funded 40 percent by property taxes in order to smooth out seasonal and annual variation in total revenue collected under this program.

WHO ACTS

Regulations for all septic tank systems are controlled by DEQ under authority granted by the Wyoming Environmental Quality Act of 1973 (Sections 35-502.18 and 35-502.19). However, the authority over the administration and enforcement of the State regulations has been given to local officials.

There is a possibility that the State of Wyoming might enact legislation at some time to establish a similar kind of program, but currently local citizens appear to prefer that the action be taken at the county level. A need exists in the three counties within the study area to designate clearly those local officials who are responsible for the management of individual waste systems. Local citizens have frequently voiced the concern that they do not know who is responsible at the State or local level for complaints and other issues associated with septic tanks. A county health department could be established in Sweetwater County. A regional health department could be established through the Uinta-Lincoln Association of Governments, or Lincoln and Uinta Counties individually could establish county health departments. Whether or not health departments are established, county or regional sanitarians could be employed to carry out the reviews and inspections of the management program.

The counties would be responsible for enacting necessary ordinances to establish and carry out a program to manage individual waste systems. These responsibilities would include, but may not be necessarily limited to, the following:

- Establish a three-part program relative to individual waste treatment and disposal consisting of review of design, inspection during construction, and inspection periodically during subsequent operation. The purpose of such reviews and inspections would be to safeguard public health and ground water quality by ensuring to the greatest extent possible that disposal systems (such as septic tanks and drain fields) are designed properly for the property being served and in accordance with site conditions such as soil types, that such systems are installed as they were designed, and that such systems continue to operate in a safe and adequate manner.
- Establish that such a program will apply to new installations as they are planned.
- Provide for employing such county-level sanitarians as needed to carry out said program in accordance with Wyoming Compiled Statutes 35-32, Appointment of Sanitarians.
- Involve consulting services, such as the Soil Conservation Service and others, as needed to first initiate the program by providing technical expertise in such matters as soils evaluations, design criteria, and setting priorities for the transition of existing systems into the program.
- Establish a system of permits, fees for the permits, collection of said fees, and the use and disbursement of monies collected in accordance with Wyoming Statute 35-32 (g) as amended.
- Apply to the State legislature for such grants as may be necessary to first establish this program and to perform the water quality monitoring. Such initial work may include, but not be limited to, more thorough mapping of soils and investigating their priorities and establishing operating rules and procedures for carrying out this program. The grants would provide for salaries and operating expenses for personnel and consultants as needed until the program is self-sustaining through permit fees and property taxes.

ENVIRONMENTAL AND SOCIAL IMPACTS

The environmental impacts of this management action would be the beneficial protection of ground and surface water bodies from contamination through individual waste disposal practices. Individual persons in Southwestern Wyoming would have increased protection against bacterial contamination in their shallow wells and deep wells that have been installed incorrectly.

Carrying out the action would not cause any further disruption of the environment than is now present and might prevent problems associated with sewage breakout from the drain fields.

Implementing this action would increase the amount of government involvement in individual private lives and would increase to a small degree the cost of building a new home.

Table 10-3

COST AND FUNDING OF SEPTIC TANK OPTION

Item	Estimated Cost	Revenue Source
Design and Construction Inspections	$180/unit	Owner (property taxes and permit fees)
Performance Bonds	$ 65/unit	Contractor
Design Changes	≥ $ 50/unit	Owner
Sludge Pumping and Disposal	$ 20/year	Owner
Maintenance Permit Inspections	$4-40/year	Owner (permit fees)
Water Quality Monitoring	Unknown	County (property taxes or State funds)

Option 2
ALTERNATIVES TO OPTION 1 FOR BRIDGER VALLEY

PROBLEM STATEMENT

Samples taken from numerous wells used for household water supply in the Bridger Valley have had high levels of fecal coliform and nitrate. The State Department of Public Health has shown these problems to be largely a result of poor septic tank operation due to soil conditions, housing densities, and other factors.

Option 1 addressed the issue of failing septic tanks. It presented a program for the management of new systems. However, this program was not considered feasible for existing systems because the locations of many septic tanks are unknown and easy access to the tanks for observation of liquid levels and pumping of sludge has not been built into most existing systems. What was recommended for existing systems under Option 1 was a manpower increase to better address problems as they arise.

Problems with existing systems will continue to occur under the approach described in Option 1, although at a decreasing rate as failing systems are corrected and maintained better. This option presents alternatives which can eliminate problems with existing failing systems at a faster rate.

MANAGEMENT ACTION

The most serious and widespread water quality problems related to failing septic tank systems have occurred in the Bridger Valley. Several alternatives to Option 1 are available for that area. They are described below:

- Conversion to Central Treatment. Mountain View and Lyman are constructing new collection systems which will eliminate some septic tanks in the area. This trend should be encouraged in order to reduce pollution in wells. Wastewater treatment capacity is being expanded in both communities to meet the increase in flows. Fort Bridger has a single-cell wastewater treatment lagoon which has limited capacity to accommodate future growth. Since the lagoon is downgradient from the existing wells, it is not a source of pollution to domestic wells. The cost to extend the collection system and eliminate some septic tanks should be investigated in the 201 Facilities Plan for the Fort Bridger area.

- Abandon Ground Water System for Public Water Supplies. One way to eliminate water quality problems associated with a particular use is to eliminate that use. With the construction of the two dams and reservoirs in the Lyman Project, the opportunity exists to draw water stored in the reservoirs for public water supplies in Bridger Valley. The ground water supplies could continue to be used for urban irrigation. The cost to extend the water supply distribution system to all users on septic tanks in Bridger Valley would be excessive because of low densities in certain areas. However, the extension of the distribution system to those areas with relatively high densities and a large number of failing septic tanks may be more economically feasible than replacing the failing septic tanks. This possibility should be investigated by the Bureau of Reclamation, the towns, and Uinta County when water supply service areas are defined.

- Irrigation Water Management. Many of the septic tank failures in Bridger Valley can be attributed to a high ground water table, which in turn is attributable in part to overirrigation of the agricultural lands. Several options were presented in Chapter 8 to reduce the amount of water applied to irrigated lands. The major purpose of these options is to reduce salinity delivered by irrigation return flow. However, any of these options will result in a lower ground water table and perhaps fewer septic tank failures. Thus, irrigation water management may have the dual benefits of reduced salinity in surface waters and reduced fecal coliform concentrations in surface and ground waters. Both benefits should be considered by the management agencies designated in Chapter 8 when evaluating the feasibility of the salinity control options.

OPTION 3
POINT SOURCE REDUCTIONS OF FECAL COLIFORM

PROBLEM STATEMENT

Municipal wastewater treatments plants were implicated in Chapter 5 as the major fecal coliform source in the study area. The following eight plants had particularly high fecal coliform concentrations in the effluent: Green River, Husky Truck Stop, Rock Springs, South Superior, Granger, Kemmerer-Diamondville, Lyman, and Mountain View. Instream fecal coliform violations have occurred below all eight plant outfalls.

MANAGEMENT ACTION

Allowable fecal coliform concentrations in plant effluents have been calculated for the eight facilities listed in the previous section. These concentrations have been termed allowable because a complete mixing of the instream flows and the effluent flows at the allowable concentrations would result in instream concentrations equal to the fecal coliform standard. The following three assumptions have been made in the calculation of allowable concentrations: the receiving waters are at their 7-day, 10-year low flows; background fecal coliform concentrations in the receiving streams are zero; and no fecal coliform die-off occurs between the plant outfalls and the water quality monitoring stations.

Allowable fecal coliform concentrations in the effluent are presented on Table 10-4. As the results in the table indicate, no dilution of the effluent occurs in Bitter Creek, Hams Fork and Blacks Fork; in other words, the effluent flows constitute the total flows in those three creeks at the 7-day, 10-year low flows. Consequently, allowable fecal coliform concentrations in the effluent have been set equal to the instream standards. By contrast, considerable dilution of the effluent occurs in the Green River and Smiths Fork. Therefore, allowable effluent concentrations are 80 times higher than the instream standard in the Green River and 40 times higher than the standard in Smiths Fork.

The action prescribed under this option is to set NPDES effluent discharge limitations for fecal coliform at or below the allowable fecal coliform effluent concentrations shown on Table 10-4. As shown on the table, achievement of the national goal would require more stringent fecal coliform removals at plants in the Bridger Valley, at Kemmerer-Diamondville, and at Granger than would achievement of the local goal. Therefore, the effluent limitations at those plants would depend on the choice of a water quality goal, and consequently on the designation of stream uses for primary or secondary contact recreation.

Regardless of which of the two goals is selected, the following changes in NPDES permit standards would be made:

- Effluent standards would be set equal to the allowable concentrations for the plants at South Superior, Mountain View, Kemmerer-Diamondville, and Lyman

- The effluent standard would be relaxed to the allowable concentration for the plants at Green River and Rock Springs
- The effluent standard would be made more stringent for the plant at Granger.

EXPECTED CONTAMINANT REDUCTION

The reductions in fecal coliform loadings have been calculated in terms of allowable effluent concentrations, which are listed on Table 10-4. Effluent loadings at these concentrations or lower from the eight municipal wastewater treatment plants listed on Table 10-4 are expected to reduce instream fecal coliform concentrations to allowable levels in the five reaches also listed on the table.

EXPECTED COST

Under the management action described in this section, five plants will be required to develop disinfection capabilities to satisfy new NPDES permit standards for fecal coliform. The capital costs have been roughly estimated at $170,000 for the Kemmerer-Diamondville plant and $80,000 apiece for the other plants.(1) Operation and maintenance costs have been roughly estimated at $20,000 per year for the Kemmerer-Diamondville plant and $10,000 per year for each of the other plants.

The difference in disinfection costs to achieve the local goal (1000 colonies per 100 ml) or the national goal (200 colonies per 100 ml) is minimal. The cost savings to Green River if the standard is relaxed and the costs to Granger if the standard becomes more stringent may also be small. The change in costs in both cases is difficult to estimate; however, it is not expected to exceed a thousand dollars in either case.

BENEFITS AND TO WHOM

Reduction of fecal coliform loadings from point sources by disinfection probably would reduce the possibilities of bacterial or viral infections caused by drinking or swimming in impure water. Fecal coliform is only an indicator of the presence of harmful bacteria and viruses. However, the connection between fecal coliform in water and infectious hepatitis is well documented in the literature. Recent findings have indicated that fecal coliform may not be as good an indicator species for the presence or absence of certain other pathogenic viruses, however.

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(1) These cost estimates assume the construction of a chlorine contact basin.

WHO PAYS

The management agency for each wastewater treatment plant would be responsible for funding the design and construction of disinfection facilities. Such facilities would be eligible for construction grant funds under the 201 program.

WHO ACTS

The Wyoming Department of Environmental Quality would write fecal coliform effluent standards into the NPDES permits for wastewater treatment plants in the study area. The prosecution of violations of the fecal coliform standards could be delayed until the communities had applied for and received grants needed to fund the design and construction of disinfection facilities.

ENVIRONMENTAL AND SOCIAL IMPACTS

While fecal coliform concentrations would be reduced in the streams of the area, residual chlorine concentrations probably would increase. Residual chlorine concentrations of 1 mg/l to 5 mg/l are typically needed to insure effluent concentrations of fecal coliform below 200 to 1000 colonies per 100 ml. The residual chlorine concentrations may be well above the instream criterion for fisheries (see Table 2-11). The concentrations of free residual chlorine, chloramines, and chlorinated hydrocarbons may have to be monitored closely below plant outfalls discharging to streams with relatively small flows. If dechlorination is found to be necessary at the plants, capital costs, and perhaps operation and maintenance costs, will increase significantly.

Table 10-4

ALLOWABLE FECAL COLIFORM DISCHARGES

Reach	7-Days 10 Year Low Flow (cfs)	Instream Criterion(1) (#/100ml)	Major Point Source Contributors	Present NPDES Standard (#/100ml)	Allowable Effluent Concentration Local Goal (#/100ml)	Allowable Effluent Concentration National Goal (#/100ml)
Lower Green River	400	200	Green River	1,000	16,000	16,000
			Rock Springs	200		
			Husky Truck Stop	1,000		
			South Superior	none		
Bitter Creek	5	1,000	Rock Springs	200	1,000	1,000
			Husky Truck Stop	1,000		
			South Superior	none		
Lower Smiths Fork	4	1,000	Mountain View	none	40,000	40,000
Middle Hams Fork	2	1,000(2) 200(3)	Kemmerer-Diamondville	none	1,000	200
Blacks Fork, Lyman to Little America	2	1,000(2) 200(3)	Mountain View	none	1,000	200
			Lyman	none		
			Fort Bridger	none		
			Kemmerer-Diamondville	none		
			Granger	17,000		

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(1) The criteria apply during the recreation season only (May 1 - September 30).
(2) Under local goal.
(3) Under national goal.

OPTION 4
POINT SOURCE REDUCTIONS OF BOD

PROBLEM STATEMENT

Dissolved oxygen concentrations in violation of the standard have occurred in the Hams Fork below the Kemmerer area and in the Green River below the confluence with Bitter Creek. The high BOD_5 concentrations in the plant effluents of Kemmerer-Diamondville, Green River, Husky Truck Stop, and South Superior may be contributing to the dissolved oxygen problems at these two locations.

MANAGEMENT ACTION

Kemmerer-Diamondville and South Superior are seeking 201 construction grant funds to build facilities capable of improving their effluents to secondary treatment standards. Green River is completing an engineering study on why its plant is not operating to its expected efficiency. The problems at the Husky Truck Stop facility have been recognized by the State and corrective measures are being taken. Thus, all four facilities with effluents frequently exceeding secondary treatment standards (30 mg/l) for BOD_5 are expected to be in compliance with secondary treatment standards within the next 5 years.

If dissolved oxygen problems persist after corrective measures have been taken at the four facilities, a Streeter-Phelps dissolved oxygen sag analysis should be run to assess if municipal treated wastewater effluents are causing the problems to persist. It is likely to be found, however, that algal respiration and decay are the sources of any continued dissolved oxygen problems.

OPTION 5
EUTROPHICATION CONTROLS TO INCREASE DISSOLVED OXYGEN LEVELS

PROBLEM STATEMENT

All of the dissolved oxygen problems in the area have been attributed at least in part to excessive algae growth and decay. As noted on Table 10-2, low dissolved oxygen concentrations have been observed in the Snake River and Green River near the reservoirs and in the middle and lower reaches of the Hams Fork. Extensive algae blooms have been observed in all of these river stretches. Algae respiration and decay in these stretches is likely to produce temporary dissolved oxygen depletions to levels below 6 mg/l.

Algae growth is promoted by large phosphorus loadings from erosion, municipal wastewater treatment plants, and manure runoff. Control of phosphorus from these sources is likely to reduce algal growth in those reaches which have been found to have low dissolved oxygen levels, and therefore, significantly improve dissolved oxygen conditions in those reaches.

MANAGEMENT ACTIONS

Eutrophication control options are described in Chapter 9.

OPTION 6
MANURE RUNOFF CONTROLS

PROBLEM STATEMENT

Marginal violations of the fecal coliform standard have occurred in four reaches of the Green River above its confluence with Bitter Creek and in the Upper Big Sandy reach. Manure runoff was the only significant fecal coliform source identified for those reaches.

Manure runoff was also identified as a fecal coliform source in Killpecker Creek, Salt Wells Creek, in Lower Smiths Fork, and in the Lyman, Church Butte, and Little America reaches of the Blacks Fork. However, municipal wastewater discharges and failing septic tanks appear to be the more important fecal coliform sources in those reaches, according to the discussion in Chapter 5.

MANAGEMENT ACTION

Manure runoff control alternatives were discussed in Option 6 of Chapter 9. The alternatives would probably be capable of eliminating fecal coliform violations caused by manure runoff. However, they are not recommended for the following reasons:

- Fecal coliform violations attributed to manure runoff are infrequent and only marginally above the standard, and any emphasis on manure control may direct attention away from the more significant and more easily controllable fecal coliform sources such as municipal wastewater discharges and failing septic tanks.

- Manure runoff controls may cause severe economic and social impacts on ranchers

- Manure runoff controls may also have to be established for wild animals in order to eliminate the fecal coliform violations, and such controls may be technically and politically infeasible

- No outbreaks of disease have been associated with fecal coliform violations attributed to loadings from manure runoff

Option 7
USE-BASED APPROACH TO WATER QUALITY

PROBLEM STATEMENT

Two water quality goals were developed in Chapter 2. One goal includes swimming and fishing as a designated use wherever attainable. This goal has been named the national goal because it complies with Section 101 (a) (2) of Public Law 92-500, which states that:

> "It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983."

The second water quality goal includes swimming and fishing as a designated use wherever it is attainable and existing or desirable. This goal, presented on Table 2-2, has been named the local goal because it represents the water quality goal developed by State and local agencies and local citizens.

The differences between the two goals were discussed in Chapter 2. The two goals designate the same reaches for fisheries in the study area. However, eight more reaches are designated for primary contact recreation (swimming) under the national goal than under the local goal. In these eight reaches, primary contact recreation has been determined to be an attainable use, but not an existing or desired use. The eight reaches are:

- Bear River, Border reach
- Big Sandy River, Upper and Lower reaches
- Blacks Fork, Lyman, Church Butte, and Little America reaches
- Hams Fork, Middle and Lower reaches.

Because of the larger number of reaches designated for primary contact recreation under the national goal, more fecal coliform problems occur under the national goal. Those fecal coliform problems under the national goal only are shown on Table 10-2 to occur in the Border reach of the Bear River, the Upper Big Sandy reach, the Lyman, Church Butte, and Little America reaches of the Blacks Fork, and the Middle Hams Fork reach.

The water pollution control program should be designed to attain the designated uses in the study area. Because the uses are different under the local and national goals, the water pollution control programs under the two goals may also be different. Concurrence must be achieved on the uses to be protected in order to define and institute the control measures necessary to protect those uses.

MANAGEMENT ACTION

Under this option the Wyoming Department of Environmental Quality (DEQ) under authority given in WS 35-502.19 and WS 35-487.19 would adopt for the three-county Southwestern Wyoming planning area the nine water use classifications defined on Table 2-1. It would also adopt either the water use designations locally developed for 52 reaches in Southwestern Wyoming and presented on Table 2-2 or the water use designations developed under the national goal. The list of use designations by stream reach has been reviewed by State and local agencies and local citizens, and has been revised to agree with comments made by those agencies and individuals; therefore it reflects the best representation of the existing, the potentially attainable and the desired uses of surface water in the study area.

The list of use designations may change from time to time. The ongoing 208 agency should obtain the necessary input from State and local agencies and local citizens to review and revise the list of use designations. The ongoing 208 agency would submit a written report to the DEQ in July of every third year, beginning in July of 1981, with the list of current use designations. This list would be included in the State Water Quality Standards for Surface Waters.

The use-based approach described in Chapter 2 and in this option will increase the complexity of the existing State use-based approach. This additional complexity and cost in administering the system must be weighed against (1) the greater protection it may afford certain types of water users and (2) the cost savings realized by eliminating water pollution control projects which do not relieve one or more of the designated impaired uses.

OPTION 8
DEVELOPMENT OF HEAVY METAL STANDARDS

PROBLEM STATEMENT

In Chapter 3, eight reaches were identified to have concentrations of dissolved metals which exceeded the water quality criteria. These reaches were 1, 6, 7, 8, 11, 13, 17, and 20. The metals which exceeded the water quality criteria were cadmium, zinc, copper, and lead. However, there has been no documented evidence of any toxicity problems in any of these reaches. Moreover, several of the reaches are considered blue-ribbon fisheries. The apparent discrepancy may be the result of one or more of the four following conditions: fish species may have adapted to the instream concentrations; the effects of the metals may be too subtle to notice without an intensive study; analytical measurements of instream concentrations may have been inaccurate; and water quality criteria may not adequately represent toxicity levels for the fish in the study area.

MANAGEMENT ACTION

Because of the importance of fishing to the economy of the study area and because of the widespread consequences in applying the water quality criteria to the study area, the four conditions listed above should be investigated. The most suspect of the four conditions would appear to be the last one, which is that water quality criteria do not adequately reflect toxicity levels for the fish in this study area. The Wyoming Game and Fish Department, in conjunction with EPA as needed, should carry out species tolerance studies to determine if the levels of heavy metals in the reaches as called out above are, in fact, harmful. A report should be prepared and submitted to DEQ and to the ongoing 208 agency in the areas in question. The report should describe which metals were found to be toxic and which metals were not found to be toxic and at what levels, for what species, and in what locations. This information will then be used for future planning purposes.

OPTION 9
WATER QUALITY MONITORING

PROBLEM STATEMENT

More confident conclusions could have been reached on some of the controls if better water quality data had been available. This section calls out some of the monitoring needs for the future within the study area.

MANAGEMENT ACTION: COORDINATED MONITORING AND TESTING PROGRAMS

DEQ and USGS are the two agencies that do the most sampling in the study area. They are expected to continue doing their sampling programs in the future. USGS conducts the routine monitoring programs, while DEQ carries out special studies as needed. These agencies are directed to the following needs:

- A fully qualified water quality testing laboratory must be maintained in the Southwestern Wyoming area. The long distances to the nearest large cities make it difficult to carry out a routine monitoring program and to obtain accurate results without a laboratory within the study area. Although DEQ cannot establish the laboratory, it can review the adequacy of any existing laboratory in the study area and recommend to the Legislature the establishment of one or more if it deems necessary.

- A flow-monitoring station should be established at the existing quality station designated Green River below Green River in order to measure contaminant loadings from Bitter Creek and the Green River area.

- The present program of monitoring phosphorus does not allow accurate prediction of loads. If a phosphorus control program is initiated, a concentrated sampling program should be started. The frequency of phosphorus monitoring, particularly in the tributaries, should be increased during high flows. Because of the large costs and benefits associated with a phosphorus control program, sampling should be done by automatic samplers to ensure more accurate results.

- Dissolved and total metals should be routinely monitored only if toxicity levels can be accurately established.

- Alkalinity and chloride are easily monitored, but levels in the study area have been adequately determined and further monitoring does not appear necessary.

- Ammonia monitoring should take place within and below population centers and should be done in conjunction with monitoring of pH and temperature. Sampling should initially be concentrated on those reaches shown on Table 3-6 to have possibly excessive ammonia concentrations.

- Water quality criteria have not been exceeded for the following chemical constituents: arsenic, barium, color, fluoride, phenol, polychlorinated biphenyls, selenium, and turbidity. It is recommended that these constituents be monitored infrequently or not at all, because no conditions in the foreseeable future are expected to increase their levels above the criteria.

- The important salinity parameters in the study area are total dissolved solids (or conductivity), sulfate, total hardness, and sodium adsorption ratio. If a salinity control program is initiated, a salinity baseline should be established throughout the Green River Basin by monitoring the four salinity parameters on a twice- monthly basis during spring and on a bimonthly basis at other times.

- The following measurements should be made monthly in Flaming Gorge Reservoir to define the pace of eutrophication: total phosphorus, dissolved oxygen, chlorophyll a, and secchi disk transparency. At least three phosphorus and dissolved oxygen measurements should be made at different depths at each sampling location.

- Monitoring of constituents which have criteria but which have not yet been monitored (see Table 2-11) does not appear necessary at this time.

The results of the water quality monitoring should be reported through the regular channels of USGS and DEQ and be stored in the STORET and WRDS systems in order to be available for future planners.

OPTION 10
DESIGNATION OF WASTEWATER TREATMENT MANAGEMENT AGENCIES

PROBLEM STATEMENT

Boomtown growth has caused rapid development of land immediately outside of the boundaries of incorporated towns and cities. Many of these areas are on individual wastewater treatment systems. However, a few of them, particularly near Rock Springs, have small collective treatment facilities. As the towns and cities grow in size and importance, pressure increases on those communities to operate the satellite facilities or to incorporate the bordering areas into the main system. This situation is currently taking place in the Rock Springs area, and is expected to occur in Green River, Kemmerer, Evanston, and Bridger Valley.

Too often the community's central treatment facility is not sized to handle the additional flows from a satellite community outside its boundaries. Even if the facility has the capacity, typically the trunk sewer mains do not. Planning for the size of facilities and trunk mains therefore must take into account the potential for growth and the potential future service area that the facility must plan to serve. Development within that boundary can then take place with the knowledge that sooner or later central treatment facilities will be provided. And development outside the area can take place with the full knowledge that individual or satellite systems are likely to be the treatment method for the long-range future.

MANAGEMENT ACTION

For the present, it is recommended that the following be designated wastewater treatment agencies for the sewage service areas under their jurisdiction:

- Rock Springs
- Wamsutter
- South Superior
- Granger
- Green River
- Afton
- Evanston
- Cokeville
- Diamondville
- Jamestown-Rio Vista Water & Sewer District
- White Mountain Water & Sewer District
- Inner City Water & Sewer District
- Lyman
- Mt. View
- Ft. Bridger Water & Sewer District
- Alpine Water & Sewer District
- LaBarge
- Kemmerer
- Thayne
- South Lincoln County Water & Sewer District
- Rock Springs Sweetwater County Airport Board
- Reliance Water & Sewer District

These agencies would be responsible for constructing, operating, and maintaining sewage treatment facilities under their jurisdiction and would be eligible to apply for and receive State and/or federal grant funds to carry out such work.

Immediate regionalization of facilities would appear to serve no purpose at the present time. Most satellite facilities are satisfying NPDES permit requirements, producing effluent necessary to meet instream water quality standards and often producing effluent of better quality than larger nearby plants. Furthermore, many of the satellite facilities would require long and costly interceptors to tie in with regional facilities.

If higher levels of treatment are required in the future, such as the removal of phosphorus or ammonia, regionalization may become economically feasible because of economics of scale. It may also become an operational necessity because advanced wastewater treatment will require more and better trained personnel to operate and maintain the facilities. Therefore, future 201 studies should address regionalization of higher effluent quality standards are placed on the facilities.

Cummunities with rapid growth and sprawl should also investigate the possibility of regionalization. Rock Springs in particular may annex bordering areas served by satellite facilities. Wyoming law provides that the major of any municipality may have extraterritorial jurisdiction under Wyoming Statute 15.1-171. This provides the major, as may be vested in him by ordinance, with jurisdiction--

- Over all places within 5 miles of the corporate limits of the city for the enforcement of health or quarantine ordinances; and
- In all matters, excepting taxation, withon 0.5 mile of the corporate limits of the city.

Attorney General V. Frank Mendicino and Special Assistant Attorney General Steven F. Freudenthal have pointed out that "it is necessary to conclude that: A county may zone up to the boundaries of the municipality; a municipality may exercise zoning authority beyond its municipal boundaries; and, within the area of overlapping jurisdiction, the more restrictive zoning requirements, whether municipal or county, are controlling (letter to Carbon County Attorney, 2 June 1976)."

WHO ACTS

For the areas of Rock Springs, Green River, Evanston, Kemmerer, Mountain View, Lyman, and Fort Bridger, the county and each municipality named would jointly develop an agreement on jurisdiction for planning for wastewater facilities within the 5-mile limits described in Wyoming statutes beyond the boundaries of each municipality, and that a plan specifically be developed that will detail what final service area is to be expected by the central treatment facility in each of those communities. The county commissioners in each of the counties may authorize some specific agency to carry out that planning within their jurisdiction.

The Wyoming Department of Environmental Quality and the U.S. Environmental Protection Agency could encourage the development of plans which evaluate regionalization through discretionary use of 201 wastewater facilities construction grant funds and other grant monies.

OPTION 11
IDENTIFICATION OF ONGOING 208 PLANNING AGENCY

PROBLEM STATEMENT

The Southwestern Wyoming Water Quality Planning Association (SWWQPA) was established for the 2-year period necessary to carry out the 208 planning project. It was not an existing agency prior to its establishment in November 1975.

Public Law 92-500 and EPA's 208 program guidance indicate that 208 is expected to be an ongoing planning program providing for future updates of the 208 plan on an annual or other frequency basis. If SWWQPA is disbanded upon completion of the initial 208 plan, then another agency is required to carry out such future updates as are necessary.

MANAGEMENT ACTION

The executive board of SWWQPA can decide to stay in existence beyond the planning period and can direct that specific activities be carried out at appropriate future intervals. The Association could continue to have full-time paid staff who could be responsibile for coordination of monitoring and control programs. It could also take on other duties as directed by the Association board such as the operation of the individual waste disposal management program, feasibility studies on erosion control in Bitter Creek, or others.

A better alternative in this study area appears to be for SWWQPA to disband and to transfer its responsibilities to the Lincoln-Uinta Association of Governments and to Sweetwater County. Reasons for this recommendation are presented below:

- Wyoming has historically had low taxes, relative to other states and this tendency suggests that Wyoming citizens prefer smaller government. Continuation of SWWQPA would perpetuate another layer of government

- The Lincoln-Uinta Association of Governments and Sweetwater Government have received wider recognition and acceptance as governmental entities than SWWQPA

- The planning and review functions required of SWWQPA in the implementation of the management plan are traditional functions of both the Lincoln-Uinta Association of Governments and Sweetwater County

- Control strategies in the Bitter Creek and Big Sandy drainages fall in Sweetwater County, have little apparent impact on Lincoln and Uina Counties in terms of economics, administration, and water quality, and therefore can apparently be planned and reviewed by Sweetwater County independent of the Lincoln-Uinta Association of Governments

- Control strategies in the Blacks Fork drainage fall in Lincoln and Uinta Counties, have little apparent impact on Sweetwater County in terms of economics, administration, and water quality, and therefore can apparently be planned and reviewed by the Lincoln-Uinta Association of Governments independent of Sweetwater County.

WHO ACTS

The Lincoln-Uinta Association of Governments and Sweetwater County would ask the State of Wyoming for designation as 208 areawide water quality management planning agencies. Upon designation, these two units of government would be eligible to receive future 208 water quality planning funds. Additional responsibilities may include, but not be limited to, the following:

- Provide local match for future 208 projects
- Review measures which will significantly change instream salinity concentrations or increase erosion and notify impacted local agencies and individuals
- Recommend designations of wastewater treatment management agencies and effluent qualities
- Provide annual recommendations on the construction grant priority list

Chapter 11
THE RECOMMENDED 208 PLAN

This chapter presents a 208 Plan for the Southwestern Wyoming area which has been developed by the consultants and staff of the Southwestern Wyoming Water Quality Planning Association (SWWQPA). The Plan is divided into three major parts: the subplan for salinity, the subplan for eutrophication, and the subplan for other issues. The technical basis for the elements of the Plan has been formed in the ten previous chapters of this report.

The elements of this Plan have been written up as resolutions to be reviewed and voted upon by SWWQPA or its successors. The resolutions, as well as a summary of this lengthy Technical Report, are presented in a companion report entitled "Management Plan, Clean Water Report for Southwestern Wyoming." This Technical Report and those resolutions which are voted upon and passed by SWWQPA or its successors will constitute the locally adopted 208 Water Quality Management Plan for Southwestern Wyoming. This locally adopted Plan will then be reviewed and approved, conditionally approved, or rejected by the Governor of the State of Wyoming and the U.S. Environmental Protection Agency.

EVALUATION CRITERIA

More options than those presented in Chapters 8, 9, and 10 were considered during the course of this 208 study. They were eliminated because they did not satisfy one or more of the four criteria presented below:

- Is the option capable of producing measureable improvements in water quality?
- Is the water quality improvement directed at alleviating the use impairments shown in Chapter 3?
- Is the option clearly definable so that another party can know what is to be done, who is to do it, and how benefits can be measured?
- Are there no obvious insurmountable political roadblocks?

All of the options in Chapters 8, 9, and 10 satisfy these four evaluation criteria.

A second set of evaluation criteria has been used to judge the chances of putting into practice those options presented in the three previous chapters. These criteria are as follows:

- Feasibility: Is the control measure technologically, legally, and administratively feasible?

- Cost Acceptability: Can the agency or individual responsible for carrying out the option afford it? Is the ratio of benefits to costs, where it can be computed, at least 1:1?

- Adverse Impacts: Are there significant adverse environmental and/or social impacts that would override the benefits of the action?

The emphasis of all these criteria is on implementation. This report alone cannot improve water quality in the study area. Recommendations from this plan and others must be implementable and implemented in order to achieve better water quality.

THE SUBPLAN FOR SALINITY CONTROL

A precedent for salinity control in the study area has been established by the Big Sandy Unit Project. The justification for this project was based on the costs of salinity to users in the Lower Colorado River Basin, hundreds of miles downstream from the study area. The approach to salinity in this study has been to determine whether salinity controls could also be recommended for the benefit of the study area or the State of Wyoming.

The salinity problems were covered in Chapter 3 and Chapter 4. The most important conclusions arrived at in those two chapters with respect to salinity were:

- The level of total dissolved solids in the Green River from Big Sandy River to Flaming Gorge Reservoir has important economic consequences for industry
- The chloride, sulfate, and total dissolved solids criteria for livestock and wildlife watering are exceeded in Killpecker Creek
- The sulfate criterion for livestock and wildlife watering is exceeded in Upper Bitter Creek
- The sulfate criterion for public water supplies is exceeded in the Green River reach, in Flaming Gorge Reservoir, in the Lyman reach of the Blacks Fork, and in the Lower Hams Fork reach
- The level of total dissolved solids in the Green River reach has important economic consequences for public water supply users
- Practices in the study area which change salinity loads or concentrations in the Green River system have important economic consequences for water users on the Lower Colorado River

Existing and future salinity sources were identified in the next two chapters. The most important conclusions arrived at in these two chapters with respect to salinity were:

- Large salinity loads are generated in the Bridger Valley and the Big Sandy drainage in the Eden Valley
- Large loads are carried by the Green River into the study area
- Approximately half of the salinity load generated in the study area is attributed to natural ground water discharges, while most of the remaining salinity is delivered in irrigation return flows
- The contact zone (see Figure 5-17) is the geographic area where surface and subsurface activities have had and will continue to have the most impact on salinity
- The contact zone passes through the Bridger Valley and the Big Sandy drainage in the Eden Valley
- The area of Mancos-type shales in the Bitter Creek drainage has the potential to generate large salinity loadings if recharge sources such as reservoirs or irrigation are provided.
- The coal export scenario predicts little change in salinity concentrations within the study area or downstream, while the energy export scenario predicts little change in salinity concentrations within the study area but a significant increase downstream
- Diversions from Fontenelle Reservoir and Big Sandy Reservoir will significantly change salinity concentrations in the Green River and downstream in the Colorado River

A subplan for the control of salinity has been developed from the nine options presented in Chapter 8. The goal of the subplan is to maintain salinity levels at or below their existing levels in the Green River system through the implementation of the most cost-effective controls. These include all salinity controls which have the least cost to society without any intolerably adverse environmental, social, or institutional impacts.

The evaluation of the nine salinity control options is accomplished on Table 11-1 according to the evaluation criteria described in the previous section. An option has been rejected as an element of the subplan if:

- It does not appear technologically, legally or administratively feasible
- The responsible individual or agency cannot afford it in the foreseeable future
- It has a benefit-cost ratio of less than one, where it can be computed
- It has major adverse environmental or social impacts which cannot be mitigated

Table 11-1

EVALUATION OF SALINITY CONTROL MEASURES

	Opinion of Feasibility			Opinion of Cost Acceptability			Opinion of Major Adverse Impacts	
					Favorable Benefit-Cost Ratio			
Option	Technological	Legal	Administrative	Within Budgetary Constraints	Within Study Area Only	Basinwide	Environmental	Social
1. The Big Sandy River Unity study	Yes	Yes	Yes	Yes	(1)	(1)	None	None
2. Sprinkler irrigation in Bridger Valley	Yes	Yes	Yes	Not for farmers or ASCS. Requires grant or cost-sharing	No	Uncertain	None	Yes
3. Improvement of irrigation efficiencies								
a. In Bridger Valley	Yes	Yes	Yes	Not for farmers or ASCS. Requires grant or cost-sharing	No	Uncertain	None	Yes
b. In Eden Valley	Yes	Yes	Yes		No	Yes	None	Yes
c. In both	Yes	Yes	Yes		No	Uncertain	None	Yes
4. Salinity control in Sublette County	Yes	Yes	Yes	Not with present priority	(1)	(1)	Uncertain	Uncertain
5. Interception of ground water in the Big Sandy recharge area	Uncertain	Uncertain	Yes	Funding source identified. Funds not committed.	(1)	(1)	Uncertain	Uncertain
6. No action	Yes	Uncertain	Yes	Yes	(1)	(1)	Yes	None
7. Salinity standards	Uncertain	Yes	Uncertain	Yes	(1)	(1)	None	None
8. Control of water resources development and drilling activities where salts can be mobilized	Yes	Yes	Yes	Yes	(1)	(1)	None	Uncertain
9. Consideration of diversion and depletion impacts	Yes	Yes	Yes	Yes	(1)	(1)	None	Uncertain

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(1) Not computed.

An amplification of some information presented on Table 11-1 and a summary evaluation of each option are presented below:

- The Big Sandy River Unit Study. This option is recommended for inclusion in the salinity control subplan. It appears to satisfy the evaluation criteria presented in the previous section.
- Sprinkler Irrigation in Bridger Valley. This option is recommended for further study. The possible types of studies are described in Chapter 8. Several criteria necessary for implementation of this option may not be satisfied. The lack of available funds and an unfavorable benefit-cost ratio for the study area argue against its immediate implementation. The basinwide benefit-cost ratio may also prove to be unfavorable after more data are collected in the study. Finally, social impacts may be intolerably severe; farming is presently a part-time occupation in Bridger Valley, and implementation of this option would require full-time farming or the hiring of irrigators.
- Improvement of Irrigation Efficiencies. This option is recommended for implementation in Eden Valley and for further study in Bridger Valley. Basinwide benefit-cost ratios may not be favorable in Bridger Valley. The social impacts described for the option above will also occur under this option. A loss of independence and self-sufficiency may be realized by farmers and ranchers in the two valleys. However, those in Eden Valley have been prepared for this possibility by the active presence of the Big Sandy River Unit study, and therefore the social impacts in that valley may be surmountable.
- Salinity Control in Sublette County. This option is recommended for further study. The only apparent roadblock to the study is a low priority on the future funding list developed by the Department of Environmental Quality. It is recommended that a salinity study in Sublette County be undertaken at least at the cursory level to justify the emphasis on salinity controls in the Eden Valley and Bridger Valley.
- Interception of Ground Water in the Big Sandy Recharge Area. This option is recommended for further study under the Big Sandy River Unit study. The project may prove to be technologically infeasible after further investigations on ground water movement in the area. Legal questions may be raised on water right issues. Environmental and social impacts are also possible, as described in Chapter 8. However, this project merits further study because of its potential to reduce salinity with apparently fewer severe environmental and social impacts than other alternatives.
- No Action. This option is not recommended for the study area. Health-related and economic-related problems have been attributed to high salinity in the area's streams. Several salinity control measures described in Chapter 8 appear to satisfy the criteria

for implementation in Eden Valley and Bridger Valley. In Bitter Creek, Killpecker Creek, and Hams Fork, no measures have been found feasible to reduce existing salinity levels and eliminate use impairments. However, future salinity increases in these creeks may be controlled by implementing Option 8 or Option 9. No action anywhere in the study area may be legally questionable because of possible conflict with 40 CFR 120, which is the set of EPA regulations on water quality standards. The legal question will be decided in court because of a law suit brought by the Environmental Defense Fund concerning the absence of instream salinity standards in the Upper Colorado River Basin.

- Salinity Standards. Instream and influent salinity standards are recommended for the protection of public water supplies and wildlife and livestock watering. Economic-related instream salinity standards are not recommended because there appears to be no sound technological basis for them. However, a wasteload allocation system for nonpoint sources and effluent standards for point sources are recommended for implementation. The wasteload allocation system for nonpoint sources is designed to maintain nonpoint salinity loadings at their present level. Questions have been raised about who should administer the system. DEQ appears to be the best choice if jurisdictional questions can be resolved.

- Control of Water Resources Development and Drilling Activities Where Salts Can Be Mobilized. This option is recommended for implementation. It may have some social impacts, such as promoting water resources development and drilling outside the study area. However, these impacts can be mitigated by consistent and equitable regulation of future development and drilling activities in the study area and in neighboring areas of Wyoming, Colorado, Utah, and Idaho.

- Consideration of Diversion and Depletion Impacts. This option is recommended for implementation. Some of the same social impacts mentioned for the previous option may occur under this option. Mitigation of these impacts appears possible.

In summary, the nine elements of the salinity control subplan are:

- Continuation of the Big Sandy River Unit study

- Inclusion in that study of an investigation on the feasibility of ground water interception in the Big Sandy recharge area

- Implementation of measures to improve irrigation efficiencies in Eden Valley

- Initiation of feasibility studies on sprinkler irrigation and other measures to improve irrigation efficiencies in Bridger Valley

- Initiation of a salinity control study in Sublette County
- Adoption of instream and influent salinity standards for the protection of public water supplies and livestock and wildlife watering
- Adoption of effluent salinity standards for point sources and a wasteload allocation program for nonpoint sources
- Regulation of water resources development and drilling activities in the contact zone and in the areas of Cretaceous (Mancos-type) shales
- Consideration of water quality impacts in all future projects involving diversions or depletions.

The results of this program are expected to be fewer health-related impacts for domestic water users in the study area, and lower economic costs of water treatment for industry and domestic water users in the study area and for downstream users outside the study area. It is likely that funds will not be available to implement all the nine elements of the salinity control subplan in the near future. Therefore, the elements of the salinity control subplan and the elements of the other two subplans have been prioritized according to importance and implementability in the final section of this chapter.

It is important to note before proceeding to the phosphorus control subplan that the benefit-cost analysis has shown no salinity control measures favorable to the study area for economic reasons alone. However, favorable benefit-cost ratios for several options have been calculated for the Colorado River basin as a whole. Therefore, emphasis has been placed on transferring some of the benefits gained by downstream users to those incurring costs in the study area. This transfer was considered necessary in order to make elements of the salinity control program implementable. The need for this transfer adds a serious complication to the salinity control program, however.

THE SUBPLAN FOR PHOSPHORUS CONTROL

Eutrophication, identified by the overabundance of algae in reservoirs, has emerged as a significant water quality problem in the Southwestern Wyoming planning area. Eutrophication can impair the recreational opportunities afforded by the reservoirs in the area. As discussed in Chapter 3, eutrophic conditions occur in the two arms of Flaming Gorge Reservoir, in the upstream regions of Palisades Reservoir, and throughout Big Sandy Reservoir and Woodruff Narrows Reservoir.

Flaming Gorge Reservoir is the most important recreational area in Southwestern Wyoming. Economic benefits derived from recreation in that area were estimated in Chapter 4 to total over $2 million annually to the study area and over $6 million annually to areas outside of Southwestern Wyoming. The case was made in that chapter that the spread of eutrophication through the reservoir threatens those benefits because of the loss of game fisheries.

Eutrophication can be measured by many different physical, chemical and biological parameters. In this study, eutrophication was measured by the clarity of the water, and water clarity in turn was found in Chapter 2 and Chapter 3 to be closely linked to the amount of phosphorus in the water. The theory was advanced that more available phosphorus caused more algae growth, which made the water less clear.

Sources of phosphorus to Flaming Gorge Reservoir were identified and quantified in Chapter 5. Nonpoint sources were found to be the most important phosphorus contributors. Geologic or natural erosion was estimated to contribute 50-60 percent of the total phosphorus loadings to the two arms of the reservoir. Other significant nonpoint sources were found to be overgrazed lands and manure runoff. Municipal and private wastewater treatment plants, the only important phosphorus point sources in the study area, accounted for an estimated 11 percent of the total loading to the two arms.

A phosphorus control subplan has been developed to control the significant point and nonpoint sources identified in Chapter 5. The subplan has two goals. The goal which has received more emphasis is the reduction of phosphorus loadings to Flaming Gorge Reservoir to permissible or desirable levels. These levels were defined in Chapter 9. A second goal of the subplan is to control eutrophication in the other reservoirs of the area.

The phosphorus control subplan is a combination of the options presented in Chapter 9. These twelve options are evaluated on Table 11-2. The same evaluation criteria are used to judge the phosphorus control options as were used for the salinity control options.

The evaluation presented on Table 11-2 clearly indicates that the phosphorus control subplan will be more difficult to implement than the salinity control subplan. There are many questions concerning the feasibility, cost acceptability, and environmental and social impacts of the options. A complete discussion of these points is included in Chapter 9. The information is summarized below for each option.

- Point Source Reductions. This option is feasible, grants appear to be obtainable in order to relieve the cost burdens on local communities, and no major adverse environmental and social impacts are apparent. The only drawback is that this option concerns sources which deliver only 11 percent of the phosphorus to the reservoir. If this option were implemented and phosphorus loadings to Flaming Gorge Reservoir were reduced by 11 percent, phosphorus levels would still be far above the permissible range, and little change would be observed in water clarity (see Figure 6-14).

- Range Mangement. Can an overgrazed, desert-like environment be revegetated to the degree where erosion is significantly controlled? Can ranchers obtain water rights for off-channel watering holes that may be required under this option? Will the Union Pacific Railroad, which owns almost half the land where range management practices are needed, be willing to fund, administer,

Table 11-2

EVALUATION OF PHOSPHORUS CONTROL MEASURES

Option	Opinion of Feasibility			Opinion of Cost Acceptability		Opinion of Major Adverse Impacts	
	Technological	Legal	Administrative	Within Budgetary Constraints	Benefit-Cost Ratio ($/pound of phosphorus)	Environmental	Social
1. Point source reductions	Yes	Yes	Yes	(1)	$5	None	None
2. Range management in Lower Muddy Creek and Little Muddy Creek drainages	Uncertain	Uncertain	Uncertain	Study funded	(b)	None	None
3. Construction of channel modifications in Middle and Lower Bitter Creek and tributaries	Yes	Yes	Uncertain	(a)	(b)	Yes	None
4. Construction of channel improvements and sedimentation ponds in Upper Bitter Creek, Killpecker Creek, Muddy Creek, and Little Muddy Creek	Yes	Uncertain	Uncertain	Study funded for Muddy Creek and Little Muddy Creek	(b)	Yes	None
5. In-lake management	Uncertain	Yes	Yes	(a)	(b)	Yes	None
6. Manure control	Yes	Uncertain	Uncertain	No	(b)	None	Yes
7. Erosion control for construction and mining activities	Yes	Yes	Yes	Uncertain at local level	(b)	None	Yes
8. Consideration of future water quality impacts	Yes	Yes	Yes	(a)	(b)	None	None
9. Study of eutrophication in Palisades Reservoir	Yes	Yes	Yes	(a)	(b)	None	None
10. Conversion to nonphosphate detergents	Yes	Yes	Uncertain	(a)	$5 to $136	None	None
11. Adoption of phosphorus standards	Yes	Yes	Yes	Yes	(b)	Indirectly yes	Indirectly yes
12. No action	Yes	Uncertain	Yes	Yes		Yes	Yes

(a) Funding source identified. Funds not committed.
(b) Value not meaningful because of uncertainties in costs and pollutant reductions.

or even permit the locally unpopular range management practices required on their land under this option? Could range management ever be socially acceptable in an area where the range management alternatives so strongly militate against the "don't-fence-me-in" attitude of the people? These difficult questions make the implementation of this alternative look doubtful. Yet its implementation may be important to a successful phosphorus control subplan, since overgrazing accounts for up to 25 percent of the total phosphorus loadings.

- Channel Modifications in Bitter Creek. This option appears feasible and may have acceptable costs, particularly because of possible flood control benefits to the Rock Springs area. Some administrative difficulties may arise because of the necessity to involve both a Federal agency (the Bureau of Land Management) and the Union Pacific Railroad in this option. The four most important criticisms of this option are environmental in nature. First, structures called for under this option would impact visual aesthetics, particularly for those travelling by railroad or by car on I-80. Second, a temporary increase in erosion may occur during construction. Third, large areas of land in the Bitter Creek basin are covered by highly saline Mancos-type shales, and any actions which involve the impoundment of water may increase ground water recharge and the leaching of these highly saline formations. Finally, an important philosophical question is whether largely geologic or natural erosion processes should be controlled for the benefit of recreationalists using an artificial impoundment such as Flaming Gorge Reservoir.

- Channel Improvements and Sedimentation Ponds in the Bitter Creek and Muddy Creek Drainages. This option appears technologically feasible, but water rights would have to be obtained for any offchannel sedimentation ponds and administration may be difficult because it involves a Federal agency (BLM) and the Union Pacific Railroad. Costs are uncertain, but may be unacceptably high. The same four environmental concerns noted for the previous option would also occur under this option.

- In-lake Management. This option may be technologically impossible in such a large water body. Environmental impacts may be severe because of the addition of large amounts of toxic chemicals to the reservoir.

- Manure Control. The same concerns brought up under the range management option apply to this option. Manure control may be important to a successful phosphorus control subplan, because manure runoff roughly accounts for 11 percent of the total phosphorus loading to the two arms of Flaming Gorge Reservoir.

- Erosion Control for Construction and Mining. This option has already been addressed at the State level, and appears implementable for many large private and public projects. Except for channelization of streams, however, the construction of highways, railroads, and housing appears to have had little regional impact on phosphorus and sediment loadings.

- Consideration of Future Water Quality Impacts. This option appears to satisfy all the criteria necessary for implementation.
- Study of Eutrophication in Palisades Reservoir. This option appears to satisfy all the criteria necessary for implementation.
- Conversion to Nonphosphate Detergents. This option addresses some of the same phosphorus sources as the first option on point source reductions. However, its benefit-cost ratio is much less favorable than the one for the other option and it has a lower phosphorus reduction potential. Therefore, this option is not recommended for inclusion in the phosphorus control subplan.
- Adoption of Phosphorus Standards. This option appears to be implementable and to have acceptable costs. Because of the uncertainties in the other options, it is not clear at this time if the phosphorus standards recommended in this option are achievable.
- No Action. This option has legal, environmental, and social uncertainties. It may be legally questionable because of a possible conflict with 40 CFR 120, EPA's regulations on water quality standards. The environmental impacts would be the eventual loss of the reservoir to eutrophication. Social impacts may include a loss of jobs in the recreation and tourist industries, and a loss in social esteem because of the degradation of a national recreation area.

Because of the many questions concerning the eutrophication control program, a cautious approach has been taken. The program has been divided into a short-range and a long-range subplan. Three of the twelve options are recommended for short-range implementation in the Flaming Gorge Reservoir watershed and four for short-range study. The options recommended for implementation include in-lake management (No. 5), erosion control for construction and mining (No. 7), and consideration of water quality impacts in future water development projects (No. 8). In order to treat the primary causes of eutrophication in Flaming Gorge Reservoir and reduce phosphorus loadings to permissible levels, however, geologic or natural erosion and overgrazing must be controlled. Four options (No. 2-4 and No. 6) address the control of these phosphorus sources. Because of uncertainties about the effectiveness of these options, and because of the major adverse environmental and social impacts which may be caused by them, these options have been recommended for further study rather than implementation.

The point source reduction option was evaluated and found to be implementable; however, it has not been recommended for implementation in the short-range. The option can be effective at reducing at most 11 percent of the total phosphorus loading to the two arms of Flaming Gorge Reservoir.

At least a 75 percent reduction is needed to achieve permissible loading levels. The thesis advanced in Chapter 2 and Chapter 3, and substantiated in Chapter 6 through modeling, is that not much change in reservoir quality will be observed until permissible levels are attained. Therefore, it was judged to be more important to divert the limited funds in the short-range to the feasibility studies on range management and geologic erosion controls, as well as implementation of certain other options in the phosphorus control subplan and the two other subplans.

The long-range plan is contingent on the results of the studies on control of geologic or natural erosion and overgrazing. If the four options addressing these sources are found to be implementable and effective, the long-range plan would include the following options: point source control (No. 1); range management and/or structural controls in Lower Muddy Creek and Little Muddy Creek (No. 2, No. 4, and No. 6); structural controls in Bitter Creek (No. 3 and No. 4); and phosphorus standards for Flaming Gorge Reservoir (No. 12). The short-range plan (No. 5, No. 7 and No. 8) would also be continued. If the four natural erosion and grazing control options are found either not implementable or not effective, then the program would be reduced to a continuation of two elements in the short-range program (No. 7 and No. 8) along with either continued in-lake management (No. 5) or no action (No. 12).

The options involved in the short-range and long-range subplans are listed on Table 11-3. Figure 11-1 shows the eutrophication control plan if long-range options are implemented. Phosphorus loads will increase under the energy export scenario or coal export scenario because of population growth. The phosphorus loading goal to the two arms of the reservoir was determined in Chapter 9 and is equal to 121 tons per year (87 tons per year to the Green River Arm plus 34 tons per year to the Blacks Fork Arm). The figure shows the large gap between the goal and the existing phosphorus loading levels.

A decision point is called out in the figure during 1982, which corresponds to the expected completion date of the grazing environment statement prepared by BLM for the Muddy Creek and Little Muddy Creek areas. Until this date, the short-range plan would be in effect. As shown in the figure, it has no significant impact on existing loadings to the reservoir. However, the short-range plan may be capable of reaching a water quality goal of fishable/swimmable waters temporarily through a combination of the preventative (Options 7 and 8), and the palliative (Option 5). On that date, the decision would be made on the effectiveness and implementability of the geologic erosion and grazing control measures. This decision would be made jointly by SWWQPA or other designated 208 agency and by DEQ.

The figure indicates a possible long-range plan if the geologic erosion and grazing controls were found implementable and effective. The slopes of the lines on Figure 11-1 indicate an estimate of the time required for implementation of the options. It has been estimated that it would take 2 years to design and construct phosphorus removal facilities at the municipal wastewater treatment plants and 10 years to implement all the controls of geologic erosion and grazing called out in the long-range plan. Given the rough

Table 11-3

PHOSPHORUS CONTROL SUBPLAN

SHORT-RANGE SUBPLAN

Implementation

5. In-lake management
7. Erosion control for construction and mining activities
8. Consideration of future water quality impacts

Further Study

2. Range management
3. Channel modifications in Bitter Creek
4. Channel improvements and sedimentation ponds in Bitter Creek, Killpecker Creek, Muddy Creek, Little Muddy Creek
6. Manure control
9. Eutrophication in Palisades Reservoir

LONG-RANGE SUBPLAN "A"
(Geologic erosion and overgrazing options not feasible)

Implementation

7. Erosion control for construction and mining activities
8. Consideration of future water quality impacts
12. No action (or perhaps continued in-lake management)

LONG-RANGE SUBPLAN "B"
(Geologic erosion and overgrazing options feasible

Implementation

1. Point source reductions
2. Range management
3. Channel modifications in Bitter Creek
4. Channel improvements and sedimentation ponds in Bitter Creek, Killpecker Creek, Muddy Creek, and Little Muddy
5. In-lake management
6. Manure control
7. Erosion control for construction and mining activities
8. Consideration of future water quality impacts
11. Adoption of phosphorus standards

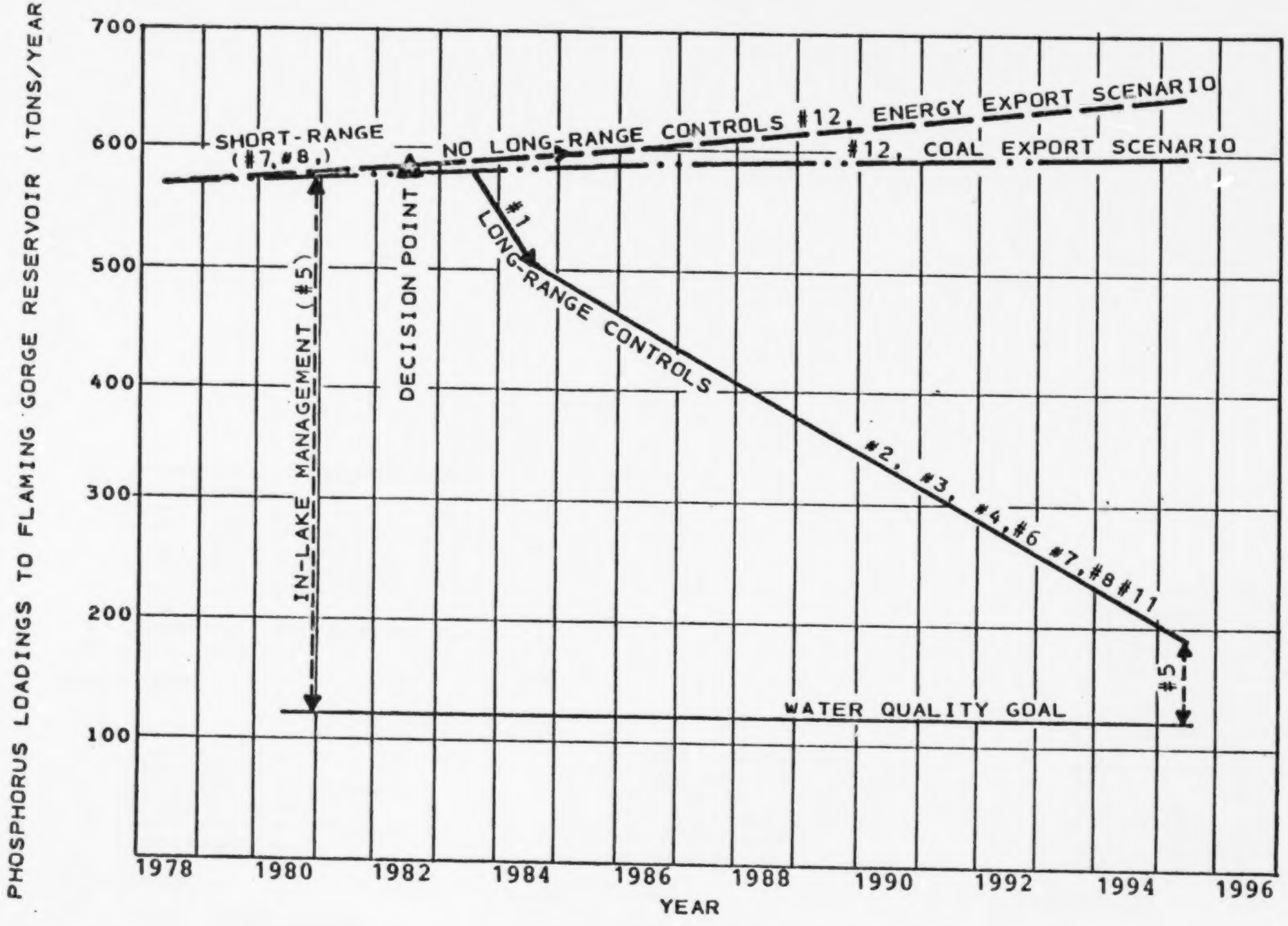

FIGURE 11-1
RECOMMENDED PHOSPHORUS
CONTROL SUBPLAN

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estimates of maximum possible effectiveness made in Chapter 9, the implementation of all elements in the long-range plan would not reduce phosphorus loadings to the permissible goal. Some in-lake management may still be needed.

It is likely the funds will not be available to implement all eight elements of the short-range phosphorus control subplan. Therefore, the elements of the short-range phosphorus control subplan and the elements of the other two subplans have been priortized according to importance and implementability in the final section of this chapter.

THE SUBPLAN FOR OTHER ISSUES

Besides salinity and eutrophication, there are a number of other issues that this 208 Plan must address. Some relate to management considerations, some to institutional questions, and others directly to water quality problems. A subplan for these other issues has been developed from the 11 options presented in Chapter 10. The evaluation of these 11 options is accomplished on Table 11-4 according to the evaluation criteria described earlier. An amplification of some information shown on Table 11-4 and a summary evaluation of each option are presented below:

- Management of Individual Waste Systems. This option is recommended for implementation. The option calls on local governments to administer the septic tank program described in this option; however, local governments appear reluctant to add staff needed to take on these responsibilities. Additional staff may mean additional unwanted costs for local governments. The program has been designed to be self-sufficient, but the State may have to absorb some water quality monitoring costs and local governments may have to absorb some administration costs.

- Alternatives to Option 1. One alternative, conversion to centralized treatment, is being accomplished in Mountain View and Lyman, and can be addressed in the 201 Facilities Plan for Fort Bridger. Not all septic tank systems will be eliminated by centralized treatment in those areas, however. A second alternative, the abandonment of the ground water system for public water supplies, is also largely being done. This action will eliminate some contaminated well sources, but will not correct or prevent failing septic tanks, which can continue to pollute surface and ground waters and impair beneficial water uses. While the conversion and abandonment alternatives are presently being implemented and will eliminate some water quality problems, they do not appear to supplant the need for a better septic tank management system, such as the one described in Option 1. The third alternative, irrigation water management, is also encouraged but appears to be a long way from implementation in Bridger Valley.

- Point Source Fecal Coliform Reductions. This option is recommended for implementation. The environmental effects of the residual chlorine in the effluent should be monitored closely, however.

Table 11-4

EVALUATION OF OTHER CONTROL MEASURES

Option	Opinion of Feasibility			Opinion of Cost Acceptability (Within Budgetary Constraints)	Opinion of Major Adverse Impacts	
	Technological	Legal	Administrative		Environmental	Social
1. Management of Individual Waste Systems	Yes	Yes	Uncertain	(1)	None	None
2. Alternatives to Option 1	Yes	Yes	Yes	Uncertain	Yes	Yes
3. Point Source Fecal Coliform Reductions	Yes	Yes	Yes	Yes	Uncertain	None
4. Point Source BOD Reductions	Yes	Yes	Yes	Yes	None	None
5. Eutrophication Controls to Increase Dissolved Oxygen	Uncertain	Uncertain	Uncertain	(1)	Yes	Yes
6. Manure Control	Yes	Uncertain	Uncertain	No	None	Yes
7. Use-Based Approach to Water Quality	Yes	Yes	Yes	(1)	None	None
8. Heavy Metals Standards	Yes	Yes	Yes	(1)	None	None
9. Water Quality Monitoring	Yes	Yes	Yes	Yes	None	None
10. Institution Responsibilities for Sewage Treatment	Yes	Yes	Yes	Yes	None	None
11. Ongoing 208 Planning Agency	Yes	Yes	Yes	Uncertain	None	None

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(1) Funding source identified. Funds not committed.

- Point Source BOD Reduction. This option is largely being implemented and its complete implementation is recommended.
- Eutrophication Controls to Increase Dissolved Oxygen. The reservations concerning the eutrophication control program were discussed in the previous section on the subplan for phosphorus control. This option should be implemented according to the schedule recommended in that section.
- Manure Control. This option is not recommended for implementation in the near future. As described in the previous section, there appears to be serious questions concerning its feasibility, its cost acceptability, and its social impacts.
- Use-Based Approach to Water Quality. This option is recommended for implementation. The locally established water quality goal appears to provide adequate water quality for the needs of the study area, and therefore, it is recommended over the national goal.
- Heavy Metals Standards. The studies recommended under this option should be initiated.
- Water Qualtiy Monitoring. This option is recommended for implementation.
- Institutional Responsibility for Sewage Treatment. This option is recommended for implementation.
- Ongoing 208 Planning. This option is recommended for implementation. Some additional staff may be needed at the local level to implement this option. Some local funds may also have to be expended in 208-related projects. The additional staff and funds are considered necessary to retain a local influence over water quality issues which have a major impact on the study area.

THE RECOMMENDED PLAN

The recommended 208 Water Quality Management Plan for the Southwestern Wyoming area is a combination of the subplan for salinity control, the subplan for phosphorus control, and the subplan for other issues. These subplans have been described in the previous sections. In the opinion of the SWWQPA staff and its consultants, the elements in each of those subplans constitute the most cost-effective set of controls which address the major water quality problems in the study area and which do not have intolerably severe environmental and social impacts. Most of the elements are controversial in some way, and the plan is likely to change somewhat as it goes through an approval process involving SWWQPA, designated management agencies, the State of Wyoming, and EPA.

The recommended water quality management plan has 29 elements. Each of these elements has a management agency to implement it and a cost associated with it. The management agencies recommended for each element and estimated costs are listed on Table 11-5. Information on management agencies and costs is discussed in more detail in Chapters 8-10.

Funds will probably not be available to implement all of the elements of the three subplans. Therefore, the elements have been prioritized according to their apparent implementability and their estimated effectiveness in alleviating water quality problems. The priority list for the 29 elements is presented on Table 11-6. At the head of the list is a 208 Plan update in 1983. This element is considered to be extremely important for four reasons. An update can keep water quality issues in the public eye. An update can provide a process through which to assimilate the new information on geologic erosion and grazing controls and conclude whether an aggressive phosphorus control program for Flaming Gorge Reservoir is feasible. An update can identify any new water quality problems in the rapidly developing Southwestern Wyoming area. Finally, an update can be a medium through which to assemble the various agencies and individuals involved in water quality management and to coordinate their efforts.

The 208 planning process in Southwestern Wyoming started three years ago with lofty ideals of alleviating the water quality problems in the area. To an outsider, the final plan presented in this chapter appears to be far from achieving those ideals. Most of the elements are further studies, more data collection programs, or new administrative responsibilities. Few elements involve the direct implementation of controls to reduce salinity, phosphorus, or other pollutants.

If shattered dreams are laid aside for a minute, however, it is clear that water quality planning has come a long way in Southwestern Wyoming. Six badly needed wastewater treatment facilities were designed with 208 funds. Some serious water quality problems were discovered in the area, and a consensus was reached on the most serious of these. Problems were quantified in terms of dollars wherever possible, as were the controls of the problems. This information was developed over the first two years of the study, and provided the basis for a draft water quality management plan, which first appeared one year ago.

Over the last year of the project, the alternative control options have been reviewed by those impacted by them. The subplans have been revised three times in order to present an implementable program in the final Technical Report and Management Plan. That year of review and compromise has not stilled all controversy surrounding elements of the plan, and yet it has brought many of the elements closer to acceptability and implementation. Realistically, some of the elements in their present form may never be implemented because of objections by one or more concerned agencies and individuals.

Along with a revised and more implementable water quality management plan, the year of review has produced in many of the management agencies a concern about water quality issues and an understanding of some of the trade-offs involved in controlling the problems. It is that concern and that understanding which may be the most important products of this 208 water

Table 11-5

SUMMARY OF RECOMMENDED MANAGEMENT PLAN

Element	Management Agency[1]	Estimated Cost
General		
▪ A 208 Plan update in 1983	EPA	$ 80,000
Salinity Control		
▪ A continuation of the Big Sandy River Unit study	BR, SCS	Not determined
▪ A study of ground water interception in the Big Sandy recharge area	BR	$ 50,000-$200,000
▪ A study of sprinkler irrigation in Bridger Valley	SCS	$ 50,000-$150,000
▪ Adoption of influent and instream water quality standards for public water supplies and instream water quality standards for wildlife and livestock watering	DEQ	Not determined[2]
▪ Adoption of effluent salinity standards for point sources and a wasteload allocation program for nonpoint sources	DEQ, SE	Not determined[2]
▪ Control of water resources development and drilling activities	BLM, BR, DEQ, SE, OGC	Not determined[2]
▪ Consideration of diversion and depletion impacts	SE	Not determined[2]
▪ Improvement of irrigation efficiencies in Eden Valley	LCD	$150,000-$300,000/yr
▪ A study of salinity controls in Sublette County	DEQ	$ 20,000-$200,000
Phosphorus Control		
▪ A study of range management	BLM	$ 25,000-$ 60,000
▪ A study of channel improvements and sedimentation ponds on Muddy Creek and Little Muddy Creek	BLM	$ 25,000-$ 60,000
▪ Consideration of future water quality impacts	DEQ, SE, EPA	Not determined[2]
▪ A study of in-lake management	USFS	$250,000-$300,000/yr
▪ Erosion controls for construction and mining activities	DEQ, WHD	Not determined[2]
▪ A study of channel improvements and sedimentation ponds in Bitter Creek drainage basin	SWWQPA	$ 20,000-$200,000
▪ A study of manure controls	WCC	Not determined
▪ A study of channel modifications in Bitter Creek	SWWQPA	$ 50,000-$150,000
▪ A study of eutrophication in Palisades Reservoir	EPA	$ 20,000-$200,000
Other Issues		
▪ Management of individual waste systems	Counties	$300-400/unit
▪ Alternatives to Option 1 for Bridger Valley	EPA, BR, towns in Bridger Valley	Not determined
▪ Point source reductions of fecal coliform	DEQ	$500,000
▪ Water quality monitoring	USCS, DEQ	Not determined
▪ Clarification of institutional responsibilities for sewage treatment	SWWQPA	No direct cost
▪ Identification of ongoing 208 planning agency	SWWQPA	No direct cost
▪ Point source reductions of BOD	DEQ	No additional cost
▪ Adoption of a use-based approach to water quality	DEQ	Not determined
▪ A study of manure controls	WCC	Not determined
▪ Development of heavy metals standards	WGF	Not determined

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(1) Agency abbreviations:

SWWQPA	Southwestern Wyoming Water Quality Planning Association	DEQ	Wyoming Department of Environemental Quality
EPA	U.S. Environmental Protection Agency	SE	State Engineer
BR	U.S. Bureau of Reclamation	OGC	Wyoming Oil and Gas Commission
SCS	Soil Conservation Service	WHD	Wyoming Highway Department
BLM	U.S. Bureau of Land Management	WCC	Wyoming Conservation Commission
USFS	U.S. Forest Service	WGF	Wyoming Game and Fish Department
USCS	U.S. Geological Survey	LCD	Local Conservation Districts

(2) Adequate cost information not obtainable. Secondary costs of this element may be large.

Table 11-6

PRIORITY RANKING OF PLAN ELEMENTS

HIGHEST PRIORITY ELEMENTS

General

- A 208 Plan update in 1983

Salinity Control

- A continuation of the Big Sandy River Unit study
- A study of ground water interception in the Big Sandy recharge area
- A study of sprinkler irrigation in Bridger Valley
- Adoption of influent and instream water quality standards for public water supplies and instream water quality standards for wildlife and livestock watering
- Adoption of effluent salinity standards for point sources and a wasteload allocation program for nonpoint sources
- Control of water resources development and drilling activities
- Consideration of diversion and depletion impacts

Phosphorus Control

- A study of range management
- A study of channel improvements and sedimentation ponds on Muddy Creek and Little Muddy Creek
- Consideration of future water quality impacts

Other Issues

- Management of individual waste systems
- Alternatives to Option 1 for Bridger Valley
- Point source reductions of fecal coliform
- Water quality monitoring
- Clarification of institutional responsibilities for sewage treatment
- Identification of ongoing 208 planning agency

Table 11-6 (Cont.)

HIGH PRIORITY ELEMENTS

Salinity Control

- Improvement of irrigation efficiencies in Eden Valley
- A study of salinity controls in Sublette County

Phosphorus Control

- A study of in-lake management
- Erosion controls for construction and mining activities
- A study of channel improvements and sedimentation ponds in the Bitter Creek drainage basin

Other Issues

- Point source reductions of BOD
- Adoption of a use-based approach to water quality

LOWER PRIORITY ELEMENTS

Phosphorus Control

- A study of manure controls
- A study of channel modifications in Bitter Creek
- A study of eutrophication in Palisades Reservoir

Other Issues

- A study of manure controls
- Development of heavy metals standards

quality planning process. They can be the seeds from which an implementable, and integrated water quality management program for Southwestern Wyoming can grow.

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APPENDIX A
WATER QUALITY AND FLOW

	Monitoring Stations	
Reach	Station Description	STORET or WRDS Number [1]
1	Snake River above reservoir near Alpine	13022500
2	Greys River above reservoir near Alpine, WY	13023000
3	Crow Creek near Fairview, WY	13025000
4	Salt River above reservoir, Etna, WY	13027500
5	Palisades Reservoir	161001, -002, -003, -004, -005
6	Bear River south of WY border-USGS	000001-10011500
	Bear River near Utah-Wyoming station	10011500
	Bear River above Bear River Ranger Station	491456-B458.45
	Bear River south of Route 89 bridge, Evanston	5424
7	Bear River above reservoir near	10020100
	Bear River north of Evanston	5425
8	Bear River 5.5 miles north of Woodruff	000003
	Bear River below reservoir near Woodruff	10020300
	Bear River below Woodruff Narrows Reservoir	00002A-10020300
	Bear River 2 miles east of Woodruff	000002
	Woodruff Narrows Reservoir	561301, -302
	Bear River south end Woodruff	5428
9	Bear River at Cokeville 5432	
10	Bear River at bridge 0.25 mile west 10-WY border	153596-151039
	Bear River at Border from bridge	2080073
	Bear River at Border, WY	10039500
	Thomas Fork at Highway 30 bridge at mouth	153564
	Thomas Fork near Wyoming-Idaho station	10041000
	Thomas Fork Creek at mouth at Highway 30 bridge	2080080
	Thomas Fork near Border, WY	10042700

11	Twin Creek at Sage, WY	10027000
12		
13	Green River near LaBarge, WY	09209400
	Green River below LaBarge	5370
	Green River above LaBarge	5371
14		
15	Green River below Fontenelle Reservoir, WY	09211200
	Green River above Big Sandy Reservoir	5368
	Green River south of Fontenelle	5369
16	Green River at Big Island, near	09216300
	Green River at Big Island bridge	5367
17	Green River near Green River, WY	09217000
	Green River at Green River, WY	09216500
	Green River at USGS gauging station at Green River	5365
	Green River above Jamestown	5366
	Green River below Jamestown	5362
18	Green River below Green River, WY	09217010
	Green River at FMC Rec. bridge	5364
19	Flaming Gorge Reservoir	560501
20	Flaming Gorge Reservoir	560503,-504,-505
21	LaBarge Creek near LaBarge Meadows	09208000
	LaBarge Creek above Green River confluence	5372
22	Fontenelle Creek near Herschler Ranch	09210500
	Fontenelle Creek at Buchas Ranch	5373
23	Slate Creek at Highway 189	5374
24	Big Sandy Reservoir	560101,-102
25	Big Sandy River below Eden, WY	09216000
	Big Sandy River at 187 bridge north of Farson	5394
	Big Sandy River at Simpson Gulch	1280

26	Big Sandy River at Gasson bridge, north	09216050
	Big Sandy above mouth 5395	
	Big Sandy 26 miles below Farson	1279
27	Pacific Creek above Jack Morrow Creek near Farson	421140109124001
	North Pacific Creek near Farson, WY	421200109124001
	Pacific Creek near Farson, WY	09215000
28	Jack Morrow Creek near Farson, WY	42104010914001
	Jack Morrow Creek, Site A	420205108551001
29	Bitter Creek above Salt Wells Creek near Salt	09216562
	Bitter Creek 6 miles east of Salt Wells	5401
30	Bitter Creek at railroad bridge, 0.25 mile east of Rock Springs	5404
31	Bitter Creek near Green River	09216950
	Bitter Creek below Little Bitter Creek	09216880
	Bitter Creek at Husky station east of Flaming Gorge Road	5400
	Bitter Creek near Rock Springs STP, downstream	5402
	Bitter Creek 3 miles east of Green River	5405
	Bitter Creek at Green River confluence	5407
32	Salt Wells Creek near Salt Wells	09216750
	Salt Wells southeast of Rock Springs	5409
	East Salt Wells Creek south-southeast of Rock Springs	5411
33	Killpecker Creek at Rock Springs	09216810
	Killpecker Creek at wool warehouse, Rock Springs	5403
34	Blacks Fork near Millburne, WY	09218500
	Blacks Fork near Millburne	1164
35	Blacks Fork near Lyman, WY	09222000
36	Blacks Fork at Granger bridge	5389
	Blacks Fork at confluence with Hams Fork	5388
37	Blacks Fork River near Little America	09224700
38	Flaming Gorge Reservoir	560502

39	West Fork of Smiths Fork near Robe	09220500
	Smiths Fork near Robertson, WY	09221000
	East Fork of Smiths Fork near Robe	09220000
	East Fork of Smiths Fork near Robertson	1275
	West Fork of Smiths Fork near Robertson	1274
40	Smiths Fork near Lyman, WY	09221650
	Smiths Fork, Route 30, east of Lyman	5420
	Smiths Fork at Cottonwood Creek confluence	5422
41		
42		
43	Muddy Creek near Hampton, WY	09222400
	Muddy Creek above Rock Creek near Carter, WY	412522110295001
44	Little Muddy Creek near mouth near Hampton, WY	413316110162401
	Little Muddy Creek near Glencoe, WY	09222300
	Little Muddy Creek above North Fork near Glencoe	413517110340001
	North Fork Little Muddy Creek at Blazon Junction	414127110332301
	North Fork Little Muddy Creek tributary no. 1 near Elko	41435111D340501
	North Fork Little Muddy Creek tributary no. 2 near Elko	414351110340901
45		
46	Viva Naughton Reservoir	561201,-202,-203
47	Hams Fork Black Pole Creek near Front I	09223000
	Hams Fork near Diamondville, WY	09224050
	Hams Fork above Kemmerer	5393
48	Hams Fork near Granger, WY	09224450
	Hams Fork at Granger 5390	
49	Henrys Fork at Linwood, Utah	09229500
	Henrys Fork near Lonetree, Utah	09226000
50		
51	Vermillion Creek near Hiawatha Creek	09235300

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(1) WRDS are 4-digit numbers; others are from STORET.

Table B-1

INDUSTRIAL SALINITY COSTS--PRESENT-DAY DEVELOPMENT, GREEN RIVER BASIN(1)(2) (1977 Dollars)

Industry	Trona
Makeup Water Volume ac-ft/yr	
400 μmho/cm^2 Salinity	1,027.00
600 μmho/cm^2 Salinity	1,540.00
800 μmho/cm^2 Salinity	2,139.00
Energy Needed Btu/yr × 10^{12}	
400 μmho/cm^2 Salinity	0.95
600 μmho/cm^2 Salinity	1.72
800 μmho/cm^2 Salinity	2.86
Annual Energy Cost \$ × 10^6	
400 μmho/cm^2 Salinity	1.43
600 μmho/cm^2 Salinity	2.58
800 μmho/cm^2 Salinity	4.29
Annual Treatment Cost \$ × 10^6	
50 mg/l Hardness	0.06
80 mg/l Hardness	0.16
110 mg/l Hardness	0.30
Total Annual Cost \$ × 10^6	
400 μmho/cm^2 Salinity	1.49
600 μmho/cm^2 Salinity	2.74
800 μmho/cm^2 Salinity	4.59

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(1) Costs for heating boiler makeup water and for treating boiler and cooling makeup water.

(2) All industries except Jim Bridger Power Plant.

Table B-2

YEAR 2000, COAL EXPORT SCENARIO, GREEN RIVER BASIN (1) (2)
(1977 Dollars)

Industry	Trona
Makeup Water Volume ac-ft/yr	
400 μmho/cm^2 Salinity	3,470.00
600 μmho/cm^2 Salinity	5,130.00
800 μmho/cm^2 Salinity	7,125.00
Energy Needed Btu/yr × 10^{12}	
400 μmho/cm^2 Salinity	3.17
600 μmho/cm^2 Salinity	5.72
800 μmho/cm^2 Salinity	9.53
Annual Energy Cost $ × 10^6	
400 μmho/cm^2 Salinity	4.75
600 μmho/cm^2 Salinity	8.58
800 μmho/cm^2 Salinity	14.30
Annual Treatment Cost $ × 10^6	
50 mg/l Hardness	0.44
80 mg/l Hardness	0.54
110 mg/l Hardness	1.02
Total Annual Cost $ × 10^6	
400 μmho/cm^2 Salinity	5.19
600 μmho/cm^2 Salinity	9.12
800 μmho/cm^2 Salinity	15.3

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(1) Costs for heating boiler makeup water and for treating boiler and cooling makeup water.
(2) All industries except Jim Bridger Power Plant.

Table B-3

YEAR 2000, ENERGY EXPORT SCENARIO, GREEN RIVER BASIN (1) (2)
(1977 Dollars)

Industry	Trona	Coal Gasification	Oil Shale	Totals
Makeup Water Volume ac-ft/yr				
400 μmho/cm^2 Salinity	4,180	1,000	940	6,120
600 μmho/cm^2 Salinity	6,270	1,500	1,410	9,180
800 μmho/cm^2 Salinity	8,708	2,083	1,958	12,749
Energy Needed Btu/yr × 10^{12}				
400 μmho/cm^2 Salinity	3.87	0.93	0.87	5.67
600 μmho/cm^2 Salinity	6.99	1.67	1.57	10.2
800 μmho/cm^2 Salinity	11.6	2.78	2.62	17.0
Annual Energy Cost \$ × 10^6				
400 μmho/cm^2 Salinity	5.81	1.39	1.31	8.51
600 μmho/cm^2 Salinity	10.5	2.51	2.36	15.4
800 μmho/cm^2 Salinity	17.5	4.18	3.93	25.6
Annual Treatment Cost \$ × 10^6				
50 mg/l Hardness	0.28	0.06	0.06	0.40
80 mg/l Hardness	0.66	0.16	0.14	0.96
110 mg/l Hardness	1.26	0.30	0.18	1.84
Total Annual Cost \$ × 10^6				
400 μmho/cm^2 Salinity	6.09	1.45	1.37	8.91
600 μmho/cm^2 Salinity	11.2	2.67	2.50	16.4
800 μmho/cm^2 Salinity	18.8	4.48	4.21	27.5

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(1) Costs for heating boiler makeup water and for treating boiler and cooling makeup water.

(2) All industries except Jim Bridger Power Plant.

Table B-4

COSTS FOR TREATING BOILER AND COOLING TOWER MAKEUP WATER AT JIM BRIDGER POWER PLANT (1977 DOLLARS)

Scenario	Water Diverted, ac-ft/yr	Annual Treatment Cost $\$ \times 10^6$ 400 μmho/cm^2 Salinity	600 μmho/cm^2 Salinity	800 μmho/cm^2 Salinity
Present Day	30,000	0.153	0.230	0.307
Year 2000, Coal Export	30,000	0.153	0.230	0.307
Year 2000, Energy Export	60,000	0.306	0.460	0.614

B-4

APPENDIX C (1)

GUIDELINES AND CRITERIA FOR DEVELOPING SITE SPECIFIC BEST MANAGEMENT PRACTICES IN STATE HIGHWAY CONSTRUCTION

A. PLANNING AND DESIGN

1. Architectural and engineering drawings and specifications must include sufficient information regarding the pollution control plan to permit prospective contractors to bid and plan intelligently, and to ensure that there will be no misunderstanding by construction personnel as to what is required. Individual contractors and developers can then support the costs of pollution control measures as part of their normal construction activities.
2. Construction contract documents will contain specific instructions as to the temporary and permanent structural and vegetative control practices required, the scheduling and coordination of activities, in addition to procedures for the maintenance and inspection of structural and vegetative controls for graded areas, borrow pit areas, sediment spoil areas and soil stockpile areas. In the event that a need for additional control becomes evident as construction progresses, the contract also should contain provisions for amendments which include such controls.
3. Provide adequate means of enforcing adequate review of and implementation of erosion control specifications in the design plans and construction contracts. The practices should be reviewed and approved by a responsible management agency, and construction activities should be monitored closely to ensure adherence to the plan and/or compliance with Wyoming Water Quality Standards.
4. Interagency and local citizen participation is one way to ensure improved pollution control before and during construction activities, and will be provided for State projects through normal procedures of the Highway Department Action Plan, and through required public participation programs of the Water Quality Management Process.

B. EROSION CONTROLS AND PROTECTION OF WATER QUALITY

1. Effective best management practices for road construction activities involve the prevention as well as restriction of runoff, erosion and other nps generation. Retain sediment at or near its origin rather than trapping and disposing of it after is has left the construction site.

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(1) From Wyoming State Highway Depar

2. No activity shall be undertaken which will permanently degrade water quality below present levels, in accordance with the antidegradation standard as described in Wyoming Water Quality Rules and Regulations.
3. Avoid channel changes wherever feasible. When channel changes are involved, complete new channels, including scour and erosion protection, before turning water into them.
4. The installation of sediment control structures normally should be done before the start of grading, clearing or other on-site land disturbances.
5. Minimize the amount of land disturbed and the length of time it is exposed by proper staging of the construction activities. In many cases, a project can be planned so it is constructed in phases wherein segments can be disturbed and stabilized in sequence rather than exposing the entire area at the same time. This requires comprehensive planning and scheduling of the various phases to maintain the overall schedule. Use stage grading, seeding and sodding.
6. The BMP's developed must be appropriate for the duration of the activity, time of year, and kind of equipment used. Avoid construction during wet season or other undesirable runoff periods to minimize sedimentation into stream. If construction is essential during such periods, sedimentation damage will be minimized by installing debris basins or using other methods to trap sediment. In addition, construction activities affecting stream channels shall be limited to those periods when such activities will have the least detrimental effect on the aquatic environment, unless emergency situations deem otherwise.
7. Prior to construction, plan to preserve as much of the natural plant cover existing on-site as possible: this can provide supplemental buffers for controlling erosion and sedimentation during construction.
8. On lands impacted by stream channel operations and lands contiguous to streams that have been altered by construction activities, reshape to as near natural conditions as possible prior to revegetating.
9. Plan structural and vegetative measures that will protect environmentally vulnerable areas. Vegetative soil stabilization practices such as direct seeding, sodding, plugging and sprigging should be an integral part of erosion control.
10. Re-vegetate disturbed lands and stream banks with native trees, shrubs,

or grasses, if possible. If no source of native vegetation is available use species which are similar to native vegetation.

11. Control the speed and volume of water runoff. (This can be controlled most easily by using short slope lengths following natural contours to avoid high cuts and fills, and blending slope grades into the natural landscape).
12. Detain stormwater on the construction site for sufficient time to trap sand size particles. Use water diversion structures to divert water away from graded areas.

    Design culverts, bridges and other facilities to pass or to protect against floods which may be reasonably expected to occur during the life of the facility. Selection of the design flood shall consider the relationships between risk and hazard of failure and the costs (monetary and nonmonetary) of providing protection.
13. All temporary roads associated with construction activities shall be constructed to prevent eroded materials from reaching streams. This may require waterbars or other structural measures.
14. Culverts or bridges shall be required on temporary roads at all points where it is necessary to cross stream courses. Such facilities shall be of sufficient size and design to provide capacity for the flow of water anticipated during the period of use of the road. When the temporary road is no longer needed for the purpose for which is was designed, all bridges and culverts shall be removed. When such facilities are removed, associated fills shall also be removed so that they will not be affected by the stream. Removed fill material shall be shaped to blend with the natural terrain, and all disturbed soil revegetated.
15. Upon completion of a project or activity, all temporary roads shall be "erosion-proofed" by cross ditches, ripping, seeding, or other suitable means. As needed, provide silting ponds or other facilities to prevent silt-laden water from entering streams.
16. Do not use soil materials to cover the decks of temporary bridges.
17. When flow in a stream course is temporarily diverted to accomodate construction or other activities, such flow shall be restored to the natural course as soon as practical and in any event prior to a major runoff season.
18. All culverts shall be bedded and backfilled in accordance with approved engineering practices.

19. Design water collection systems installed to protect roads or facilities so that waters turned onto slopes or into natural channels will not exceed the safe capacity of the slopes or channels.

20. Riprap or other erosion protection materials should be of sufficient size and placed in such a manner as to withstand peak flows comparable to a 25-year flood except where associated with major bridges which are designed for passage of a 50-year flood.

21. Riprap or other protection materials shall extend below the bed of the stream sufficient to protect against the predicted or recorded 25 or 50 year flood occurrence, as needed based on case by case evaluations.

22. Use riprap material that is of a quality that will not deteriorate during the length of time that it is determined to be needed.

23. Place riprap and other erosion protection material in such a manner as to prevent any downstream erosion.

24. Roadway sections parallel and contiguous to stream channels shall be so designed, constructed and maintained to minimize concentrated surface runoff from the roadbed and slopes. Special design features such as slope drains, insloping, crowning, berms, or other facilities shall be provided.

25. Conduct construction operations to prevent debris from entering stream channels. In the event some debris is deposited and is detrimental, it shall be removed in a manner that least disturbs the channel and adjacent land. Cable yarding or handwork are usually acceptable.

26. In road construction, maintenance, and other earth-moving activities, place the toe of overcast material above the high-water line. If the structural barriers shall be used to prevent fill material from being transported downstream.

27. Avoid operating wheeled, track-laying or other heavy equipment in stream courses to the extent possible.

28. Locate and treat construction equipment service areas so as to prevent gas, oil or other contaminents from washing or leaching into streams and groundwaters. Storage of oils and hazardous substances must be conducted in accordance with P.L. 92-500; Section 311 (Spill Prevention Control and Countermeasures Plans, and Federal Register 38 (no. 237) Part 112).

29. Remove borrow materials from stream channels only where this is not detrimental to water quality, fisheries, channel hydraulics or recreational values.

30. Provide for proper disposal of sanitary wastes so there is no discharge into streams.

C. PROTECTION OF AQUATIC LIFE

1. Protect or replace streamside vegetation when its removal can result in:
   a) Increased stream temperature detrimental to aquatic habitat.
   b) Increased turbidity, bedload, and suspended solids which would be detrimental to fish-spawning beds or other aquatic habitat.
2. During construction and other activities affecting channels, protect areas containing fish spawning beds; defer such activities above spawning areas if they adversely affect eggs or alevins in the gravel.
3. When channel changes or alterations are the best alternative, provide mitigating measures to foster replacement of the aquatic habitat to as near natural conditions as is possible.
4. Where channel changes are deemed necessary, maintain natural channel velocities in the afffected stream reach. This will be assured by installing drop structures, by constructing acceptable meanders, or by other approved methods. Where drop structures are installed they should be designed to permit fish passage, if this is an established occurrence.
5. Culverts shall be placed in a position to allow for fish passage, in all Class I and II streams.
6. Where water velocities are increased by the placing of a bridge or culvert or other activity, precluding established fish movement upstream, install suitable facilities to allow for unrestricted fish passage.

D. RECREATION AND AESTHETICS

1. In recreation areas, the following criteria should be followed:
   a. Along altered streambanks provide slopes which are not barriers to recreation use.
   b. Unless absolutely essential for the purpose of correcting an existing channel problem, to protect life and/or property, or to enhance the aquatic environment, avoid stream channel changes and encroachments on streams within or contiguous to establish or proposed recreation areas.
   c. If access along a streambank is needed under a bridge span, to be built over a large stream, provide a sufficiently long bridge to

provide room for such access.

d. Where streams offer boating or floating opportunities, allow for safe passage around or through structures or alterations and do not detract from scenic qualities.

e. Where channelization is done, shape and re-vegetate the area in a manner compatible with recreation use.

2. Consider the total scenic value in designing and constructing a road that parallels a stream. For example, a stream channel change, properly designed and constructed, might result in a road with less adverse visual and physical impact than would construction of the road across a steep slope.

E. POST-CONSTRUCTION ACTIVITIES

In order to assure that water quality objectives are met, certain post-construction practices must be followed. In general, these practices are simply the application of those elements of a good road maintenance program that apply to water quality management.

1. Highway Facility. The roadway, roadside, appurtenances, and structures are to be cleaned as needed. This requires a systematic inspection program. Of particular interest are storm sewers and urban streets. Oil, grease and decaying matter should be removed after a storm and frequent street sweepings used to prevent the concentration of pollutants on the street surface.
2. Ice Control. When abrasives are used to provide traction, select a stockpile site that will not contaminate a water source. If this is not possible, use precautionary measures that prevent drainage into a water source. Use only enough salt in the stockpile to keep it workable (usually 3% or less). When salt is relied on solely as a melting agent for ice control, its use should be accompanied with a timely sweeping and flushing program.
3. Slide and Waste Materials Disposal. Select a disposal site that will not contaminate a water source. Suitable erosion control measures should also be a part of the disposal action.
4. Pesticides and Herbicides. Follow manufacturers recommendations. Where use is restricted, they must be applied by operators certified by the State of Wyoming.
5. Point Source Discharge. Must obtain a permit from State Department of Environmental Quality.

6. Litter. Dispose of in land fill approved by the DEQ.

7. Sediment Traps and Other Erosion Control Structures. Follow a systematic inspection, cleaning, and repair program. Follow appropriate management practices in cleaning and repairing facilities.

8. Asphalt, Crushing and Screening Operations. Comply with Department of Environmental Quality operating permit system.

9. Oil and Hazardous Materials. A Spill Prevention and Counter Measure Control Plan is required for all asphalt pavement plants and fuel storage areas wherein measures must be taken to prevent and control asphalt and oil spills at plant sites.

   Support is given to the States Hazardous Spill Plan which pertains to measures to be taken in the event of spillage of hazardous materials while in transit.

10. Roadway Contamination. When tests indicate that the highway facility is causing a water quality problem, develop an appropriate solution based on the best available technology.

F. LEGAL RESTRICTIONS

All construction activities must comply with legal restrictions and requirements imposed by the following Federal and State regulations.

a. Wyoming Water Quality Standards and related stream classifications, as specified in the State 106 Program Plan.

b. National Pollutant Discharge Elimination System (NPDES) permit requirements for point source discharge.

c. National Environmental Policy Act requirements.

d. Section 404 Dredge and Fill Permits (See Appendix D).

e. Section 311, Public Law 92-500, Spill Prevention Control and Countermeasure Plans; Federal Register 38 (no. 237) Part 112.

APPENDIX D
SEPTIC TANK MAINTENANCE PERMIT

Section 1. Purpose

It is recognized that proper maintenance of septic tanks will increase the useful life of all onsite sewage disposal systems which rely on solid absorption of septic tank effluent. To further the purpose of increased life of such onsite disposal systems, and to protect the health, safety and welfare of the inhabitants of the County of __________, the County of __________ hereby establishes a septic tank maintenance permit program.

Section 2. Permit Required

No owner may occupy, rent, lease, live in or reside in, either seasonally or permanently, any building, residence, or other structure serviced by a private domestic sewage treatment and disposal system, unless the owner has a valid septic tank maintenance permit for that system issued in his name by the __________ (County sanitarian or other responsible official). Owner is defined to mean a natural person, corporation, the state or any subdivision thereof.

Section 3. Fee

A fee of $ _____ shall accompany each application for the septic tank maintenance permit.

Section 4. Permit Application

Application for a septic tank maintenance permit shall be made to the _________ (County sanitarian or other responsible official) on forms supplied by him. All applications shall state the owner's name and address, the address or location of the private sewage system and shall contain the following statement:

> "I certify that on __ day of __________, 19__, I inspected the septic tank located at the address stated on this application, and I (check one):
>
> ___ pumped all sludge and scum out of the septic tank, or
> ___ found that the volume of sludge and scum was less than 1/3 of the tank volume, and I did not pump the septic tank.

Signature

Sanitary License Number

Section 5. Issuance

The ____________ (County sanitarian or other responsible official) shall issue a permit to the applicant upon receipt of the fee and a completed application, properly signed by a person licensed to service septic tanks and stating his sanitary license number. The permit shall include on its face all information contained in the application and shall contain the date of issuance.

Section 6. Validity

The permit issued under this section shall be valid for a period of __ years from the date of issuance.

Section 7. Sale of Property

When property containing a private domestic sewage system is sold the new property owner, prior to occupying, renting, leasing, or residing in the building, residence or structure served by the system, shall make application for and received a septic tank maintenance permit; however, the system may be used for a period not to exceed 30 days after making application for a permit.

REFERENCE: Stewart, David E., "Legal, Planning and Economic Considerations of Onsite Sewerage Systesm," Prepared for the Small Scale Waste Management Project, University of Wisconsin, 1974.